VIEWS OF THE CARNEGIE IN VARIOUS HARBORS OF THE WORLD

...elton, dressed in honor of ... Day
...ock, Balboa, Canal Zone
...g Edward Cove, South ...a.

4 Off Old Point Comfort with port signals flying, at the conclusion of Cruise VI

2 At Buenos Aires alongside Yacht Club.
5 At Honolulu
7 Off Lyttelton, starting circumpolar cruise

RESEARCHES OF THE DEPARTMENT OF TERRESTRIAL MAGNETISM
VOLUME V

OCEAN MAGNETIC AND ELECTRIC OBSERVATIONS, 1915-1921

MAGNETIC RESULTS

BY
J. P. AULT

ATMOSPHERIC-ELECTRIC RESULTS

BY
J. P. AULT AND S. J. MAUCHLY

SPECIAL REPORTS

W. J. PETERS: The Hudson Bay Expedition, 1914

J. P. AULT: Navigation of Aircraft by Astronomical Methods

LOUIS A. BAUER, W. J. PETERS, and J. A. FLEMING: The Compass-Variometer

LOUIS A. BAUER: The Sunspot and Annual Variations of Atmospheric Electricity with Special Reference to the *Carnegie* Observations, 1915-1921

S. J. MAUCHLY: Studies in Atmospheric Electricity Based on Observations Made on the *Carnegie*, 1915-1921

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OCEAN MAGNETIC AND ELECTRIC OBSERVATIONS, 1915-1921.

INTRODUCTION.

This publication is the fifth of the series by the Department of Terrestrial Magnetism, bearing the general title "Researches of the Department of Terrestrial Magnetism," and is the second volume containing results of ocean magnetic and electric observations. Volume I is entitled "Land Magnetic Observations, 1905-1910." Volume II, "Land Magnetic Observations, 1911-1913, and Reports on Special Researches," contains besides the magnetic results the following reports: Research Buildings of the Department of Terrestrial Magnetism, by L. A. Bauer and J. A. Fleming; Magnetic Inspection Trip and Observations during Total Solar Eclipse of April 28, 1911, at Manua, Samoa, by L. A. Bauer; Results of Comparisons of Magnetic Standards, 1905-1914, by L. A. Bauer and J. A. Fleming. Volume III, "Ocean Magnetic Observations, 1905-1916, and Reports on Special Researches," is the first volume of ocean results and includes also reports as follows: Results of Atmospheric-Electric Observations made aboard the *Galilee* (1907-1908), and the *Carnegie* (1909-1916), by L. A. Bauer and W. F. G. Swann; Some Discussions of the Ocean Magnetic Work, by L. A. Bauer and W. J. Peters. Volume IV, "Land Magnetic Observations, 1914-1920, and Special Reports," contains the magnetic results and reports entitled: Construction of Non-Magnetic Experiment Building of the Department of Terrestrial Magnetism, by J. A. Fleming; Dip-Needle Errors Arising from Minute Pivot-Defects, by H. W. Fisk; A Sine Galvanometer for Determining in Absolute Measure the Horizontal Intensity of the Earth's Magnetic Field, by S. J. Barnett; Results of Comparisons of Magnetic Standards, 1915-1921, by J. A. Fleming.

The present volume (V) is devoted to the final results of ocean magnetic and electric observations made aboard the *Carnegie* in the Atlantic, Indian, Pacific, and Southern oceans during 1915-1921. The appended reports relate to auxiliary observations made aboard the *Carnegie* or to special investigations.

The Director (Louis A. Bauer) and the Assistant Director (J. A. Fleming) of the Department desire to emphasize the successful manner in which the commanders of the *Carnegie* and the members of their scientific staffs have performed their respective responsibilities.

ACKNOWLEDGMENT.

The members of the *Carnegie's* scientific staffs, whose devotion and unflagging interest have made possible the accummulation and reduction of the data presented in this volume, were:

CRUISE IV, MARCH 1915 TO MARCH 1917

J. P. AULT, master of the vessel and in charge of scientific work
H. M. W. EDMONDS, second-in-command, chief magnetic observer and navigating officer, and surgeon.
H. F. JOHNSTON (to April 1916), observer in charge of atmospheric-electric work
I. A. LUKE (to October 1916), magnetic observer and assistant atmospheric-electric observer and navigating officer
B. JONES (April 1916 to March 1917), observer in charge of atmospheric-electric work
F. C. LORING (November 1915 to October 1916), magnetic observer and computer
A. D. POWER (from October 1916), magnetic observer and assistant atmospheric-electric observer and navigating officer.
H. E. SAWYER (to November 1916), magnetic observer and computer
L. L. TANGUY (from October 1916), magnetic observer and computer
N. MEISENHELTER, stenographer-recorder, meteorological observer, computer, and assistant navigating officer.
S. J. MAUCHLY (March and April 1915), completing installation of new atmospheric electric equipment.

CRUISE V, DECEMBER 1917 TO JUNE 1918

H. M. W. EDMONDS, master of the vessel and in charge of scientific work
A. D. POWER, second-in-command, chief magnetic observer and navigating officer
B. JONES, observer in charge of atmospheric-electric work
L. L. TANGUY, magnetic observer and assistant navigating officer
J. M. MCFADDEN, magnetic observer and assistant atmospheric-electric observer
W. E. SCOTT, stenographer-recorder, meteorological observer, and computer

CRUISE VI, OCTOBER 1919 TO NOVEMBER 1921

J. P. AULT, master of the vessel and in charge of scientific work
H. F. JOHNSTON, second-in-command, chief magnetic observer and navigating officer
R. R. MILLS (to October 1921), magnetic observer, assistant navigating officer, and stenographer
A. THOMSON, observer in charge of atmospheric-electric work
H. R. GRUMMANN, magnetic observer, assistant atmospheric-electric observer, and assistant navigating officer
R. PEMBERTON (to August 1921), surgeon, recorder, computer, and meteorological observer
F. A. FRANKE (October and November 1921), surgeon and recorder
LOUIS A. BAUER, director of the Department, accompanied the party during October and November 1921, taking active part in the magnetic observations and computations

MAGNETIC RESULTS OBTAINED ABOARD THE CARNEGIE 1915 - 1921

By J. P. Ault

Temporary, removable desks were placed in the chart room for use of the observers for the computation and reduction work.

Specially constructed non-magnetic heating stoves, built of sheet copper, brick lined, with bronze castings for top and base, were used in the forecastle and in the cabin during the cruises in cold weather.

SYNOPSES OF THE CARNEGIE'S CRUISES IV, V, AND VI, 1915-1921

CRUISE IV, MARCH 1915 TO MARCH 1917

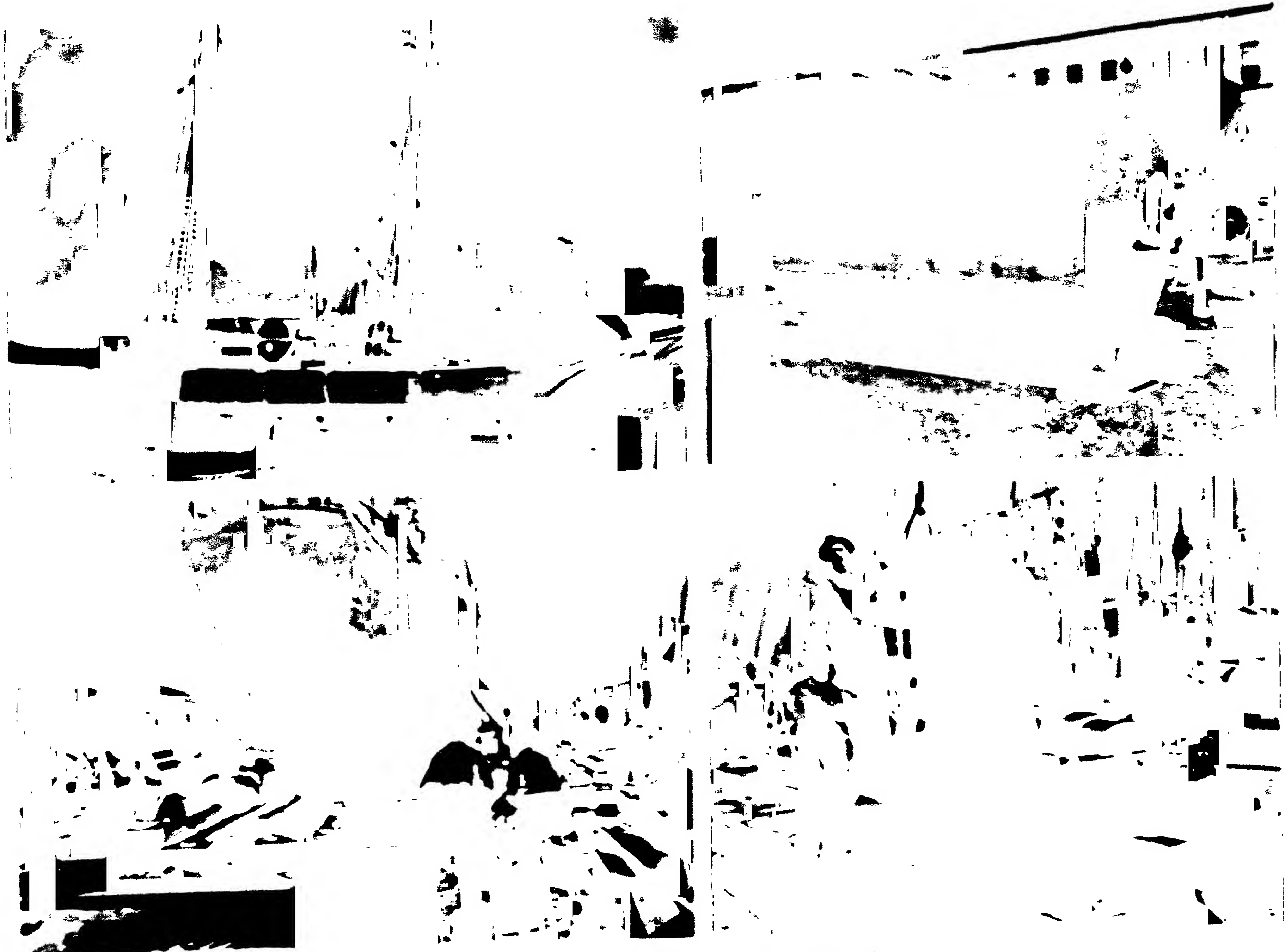
After the completion of Cruise III, the *Carnegie* was out of commission for a few months, during which time an observatory was built, just abaft the after dome, for the housing of the new instruments used in the [illegible] of the electrical state of the atmosphere. An additional stateroom on the starboard side of the cabin was provided for the accommodation of an extra observer. The bottom of the vessel was sheathed with a copper alloy, for tropical waters, and a belt, 4 feet wide, consisting of brass plates, one-quarter inch thick, was added along the water-line to afford some protection against the ice conditions likely to be encountered on the forthcoming cruise. The alterations were made at Hoboken by Tietjen and Lang, according to plans and specifications of the naval architect, H. J. Gielow, of New York, under the immediate supervision of J. P. Ault, as representative of the Department of Terrestrial Magnetism. These improvements were satisfactorily completed by February 17, 1915, on which day the *Carnegie* returned to her berth in Beard's Yacht Basin, at Brooklyn, to be put in commission. While the above work was being done the magnetic instruments were examined, repaired, or altered in the Department shop as required for Cruise IV, and their constants were redetermined.

After a final inspection of the vessel by the Director and W. J. Peters, the *Carnegie*, on March 6, left Brooklyn, under J. P. Ault's command, for Gardiners Bay, where she was successfully swung on March 7 and 8, preparatory to putting to sea. This was the *Carnegie's* fifth visit to Gardiners Bay for the purpose of swinging ship. The result of these swings, made in 1909, 1910, 1913, 1914, and 1915, confirm the existence of local magnetic disturbance in Gardiners Bay and furnish the desired control on the accuracy of the magnetic work aboard the *Carnegie*. W. F. G. Swann remained on board to the last moment to complete the installations and tests of the new atmospheric-electric instruments which had been constructed in the Department shop for this cruise, in accordance with his [illegible]. In this work he was [illegible] by S. J. Mauchly and H. F. [illegible]

The *Carnegie* sailed from Gardiners Bay on March 9, bound for Colon, Panama. The passage to Colon was made in about 16 days, during which observations of at least one magnetic element, and usually of all three, were made on every day of the stormy passage. Two deaths from sickness occurred during this [illegible], namely, A. H. Sorensen, cook, March 11, and W. Stevens, cabin boy, March 24. At Colon the ship instruments were compared with the land instruments, and a new repeat station was established. Unfortunately the previously occupied stations in the vicinity of Colon are now [illegible] affected by the large construction operations. On April 4 the *C*[illegible] [illegible] both anchors in a fierce norther, but finally the [illegible] held. She was subsequently towed to a pier by the tug *Porto Bello* and the dredge *Caribbean*.

The *Carnegie* was next taken through the canal (see Pl. 4, Figs. 3 and 4) and then she set sail in the Pacific Ocean on April 12 from [illegible] bound for Honolulu. After 39 days at sea, during which 73 determinations were made of the [illegible] declination and 39 each of inclination and intensity, [illegible] a swing of the ship, the *Carnegie* [illegible] her arrival at Honolulu on May 21. A [illegible] of [illegible] was [illegible] and [illegible] the ship's magnetic instruments and those of the [illegible] M[illegible] C[illegible]tory (see Pl. 4, Fig. 1), operated by the United States Coast and Geodetic Survey, by

PLATE 2



VIEWS AT BALTIMORE DURING REPAIRS OF THE CARNEGIE, 1919

which a correlation with other magnetic observatories and standards was effected. Every facility for carrying out these comparisons at the observatory was rendered by the observer-in-charge, W. W. Merrymon. On June 29 and July 3 the *Carnegie* was swung off Pearl Harbor, in about the same locality as that of the *Galilee's* swing of 1907. The results confirm the large differences which had been indicated by the *Galilee* swing, between the values of the magnetic elements at the place of swing and at the observatory, and they also give a means of supplying an additional determination of the constant A of the deviation formula for the *Galilee* at Honolulu. The place of swing can not be surrounded by land stations and hence can not be controlled by land observations. This shows another advantage of a non-magnetic vessel over a vessel with deviations in a magnetic survey of the oceans. After all the labor of planning, observing, and swinging ship, and the tedious computations of the deviation parameters for a vessel having deviations, one is confronted with the fact that hardly one of the few values of A which can be observed during a cruise is wholly above the suspicion of being affected by local disturbance. One can only hope that the effect is neutralized in the mean of a number of observations at the ports available.

On July 20, 1915, the *Carnegie* reached Dutch Harbor (see Pl. 4, Fig. 7), having sighted the Bogosloff Islands. The commander's report on the sighting of these islands reads:

"The Bogosloff Islands were seen at a distance of 3 miles at 2 a. m., July 20. There are two islands at present, the eastern one terminating in two high twin peaks with sharp points at the top, the western one having one high mountain with a broad top."

When the *Carnegie* arrived at Dutch Harbor she had already covered 10,158 nautical miles of her present cruise, in 73 days of sailing, at an average of 139 miles per day. During this period 101 values of the magnetic declination and 56 each of inclination and intensity were observed at sea; besides an elaborate program of observations in atmospheric electricity was carried out. Observations for determination of the amount of atmospheric refraction have been continued, as also the usual meteorological observations.

The magnetic declinations observed on the *Carnegie* from Brooklyn to Dutch Harbor, March–July 1915, showed that there had been a steady improvement in the nautical charts since the data obtained during the previous cruises of the *Galilee* and *Carnegie* had become available to hydrographic bureaus. The chart corrections reached a maximum value of about 1°5 in the region of the Pacific, between Panama and Honolulu, not previously covered by these vessels.

August 5, 1915, the *Carnegie* started on her long continuous passage to Lyttelton, New Zealand. Heavy weather was encountered immediately, and it was impossible to swing ship until August 15, just before leaving the Bering Sea. The farthest north was 59° 33′. The 180th meridian was crossed on August 13, the date August 14, 1915, being omitted. After clearing the Aleutian Islands, the course followed was south practically along the 165th meridian to New Zealand. On September 6 a terrific hurricane from the southwest was encountered. It was necessary to take in all sail and run before the storm, and for 17 hours a speed of 9 knots was made under bare poles. The vessel stood the strain well, but everything was wet on board, the hurricane driving the rain into every crack and opening. Wake Island was passed in the morning of September 12. After passing the first of the Marshall Islands, it was deemed best to keep well to the east on account of prevailing easterly winds and westerly set of the currents. It was necessary to pass considerably to the westward of the Santa Cruz-Solomon Islands passage while near the equator, but favorable conditions made it possible to weather the Solomon Islands, the engine operating during calms.

After passing the Solomon Islands the *Carnegie* was driven to the westward by the prevailing southeast winds and had to tack twice to avoid the Indispensable Reefs. These reefs were passed October 12, and all the islands and reefs in the Coral Sea were safely cleared. As the Coral Sea was entered, the winds drew somewhat more to the southward, making it necessary to near the Australian Coast off Brisbane. Good winds were blowing across the Tasman Sea, and the light on South Island, New Zealand, east entrance to Foveaux Strait, was made early in the morning of October 31. On account of the slow trip, it was decided to pass through the strait; just before clearing the east end of the strait at sunset, the wind shifted to the southeast, making it necessary to use the auxiliary power. Fortunately, the engine was in good condition and enough coal was reserved for such an emergency. Again, in trying to round Banks Peninsula to enter Port Lyttelton, the wind shifted ahead. With the engine and fore-and-aft sails, however, it was possible to tack to advantage against the wind, thus saving a delay of a day or more in entering port. On November 3 the *Carnegie* entered the harbor at Lyttelton.

Upon only one occasion during the trip did the engine fail to operate, and the cause for this failure was definitely placed. It has proved its value on several occasions and has run well. During the cruise, various and unusual currents were noted. The winds encountered were light and baffling; very rarely were the yards braced square for a fair wind. The total number of miles on the passage, Dutch Harbor to Lyttelton, was 8,865, giving an average of 100 miles per day for 89 days.

Local magnetic disturbances were noted on September 18 near Marshall Islands, October 15 west of Chesterfield Reefs and Islets, October 20 and 21 near the coast of Australia, and October 31 in Foveaux Strait. The aurora australis was seen on the nights of November 1 and 2, consisting of long beams of white light projected vertically from the southern half of the horizon.

Lyttelton was reached with over 6 tons of coal remaining in the bunkers, 40 gallons of kerosene, and 600 gallons of water. It was not necessary to issue a restricted quantity of water per day to each man, as all did their best to economize in the use of fresh water. A salt-water shower bath, connected with the deck pump, was in position ready for use at all times. The health of the party was good during the entire trip.

A stay of 33 days at Lyttelton was necessary for the completion of the observational work and comparisons at the Christchurch Magnetic Observatory and for the overhauling and outfitting of the vessel. During this stay at Lyttelton, as also during the subsequent one, the work of the *Carnegie* was facilitated by certain officials, and by Professors Farr and Chilton, of Canterbury College, and Director Skey, of Christchurch Observatory.

December 6 the *Carnegie* left Lyttelton for a sub-Antarctic circumnavigation cruise (see Pl. 1, Fig. 7). The 180th meridian was crossed on December 9, so that date was repeated as December 9 (2). The vessel arrived at King Edward Cove, South Georgia, on January 12, 1916, going the last 24 hours under her own auxiliary power. She again sailed on the 14th, being towed out of harbor against a heavy head wind by the steam whaler *Fortuna*. Icebergs (see Pl. 5, Fig. 7) became more numerous and fog was almost continuous. However, January 18 was the only day on the entire trip in southern waters on which it was impossible to obtain observations for the magnetic declination. On January 22 the vessel passed along the north coast of Lindsay Island about 3 miles offshore. The *Carnegie's* track of 1911 to the westward of Australia was twice intersected for the determination of secular change (see Pl. 11). Lyttelton was reached on April 1, 1916. This sub-Antarctic cruise, accomplished as far as known for the first time in a single season, was made practically between the parallels of 50° and 60° south until the neighborhood of Australia was approached, when it became necessary, on two occasions, to cross somewhat north of the 50th parallel. Its aggregate length was 17,084

nautical miles, the time of passage 118 days, and the average day's run 145 miles. For a more complete account of this passage, see J. P. Ault's report, pages 139 to 143; also view on Plate 1, Figure 6.

After a stay of nearly 7 weeks, the *Carnegie* again left Lyttelton for the last time on this cruise, being towed out to sea on May 17 by the tugboat *Lyttelton*. Light head winds and calms were encountered, so the engine was started to gain an offing, running all night. For five days the wind held northeast, forcing the vessel well toward the Chatham Islands. May 22 was repeated, on crossing the 180th meridian. On May 23 favorable winds were encountered for the first time, and for three days fair winds were enjoyed. Then northerly winds and calms made it necessary for the course to be taken westward near the Kermadec Islands. On June 1 the wind was again favorable, but thereafter, until arrival at Pago Pago, it was necessary to sail close-hauled, with northeast to northwest winds. Landfall was made with some difficulty on account of the

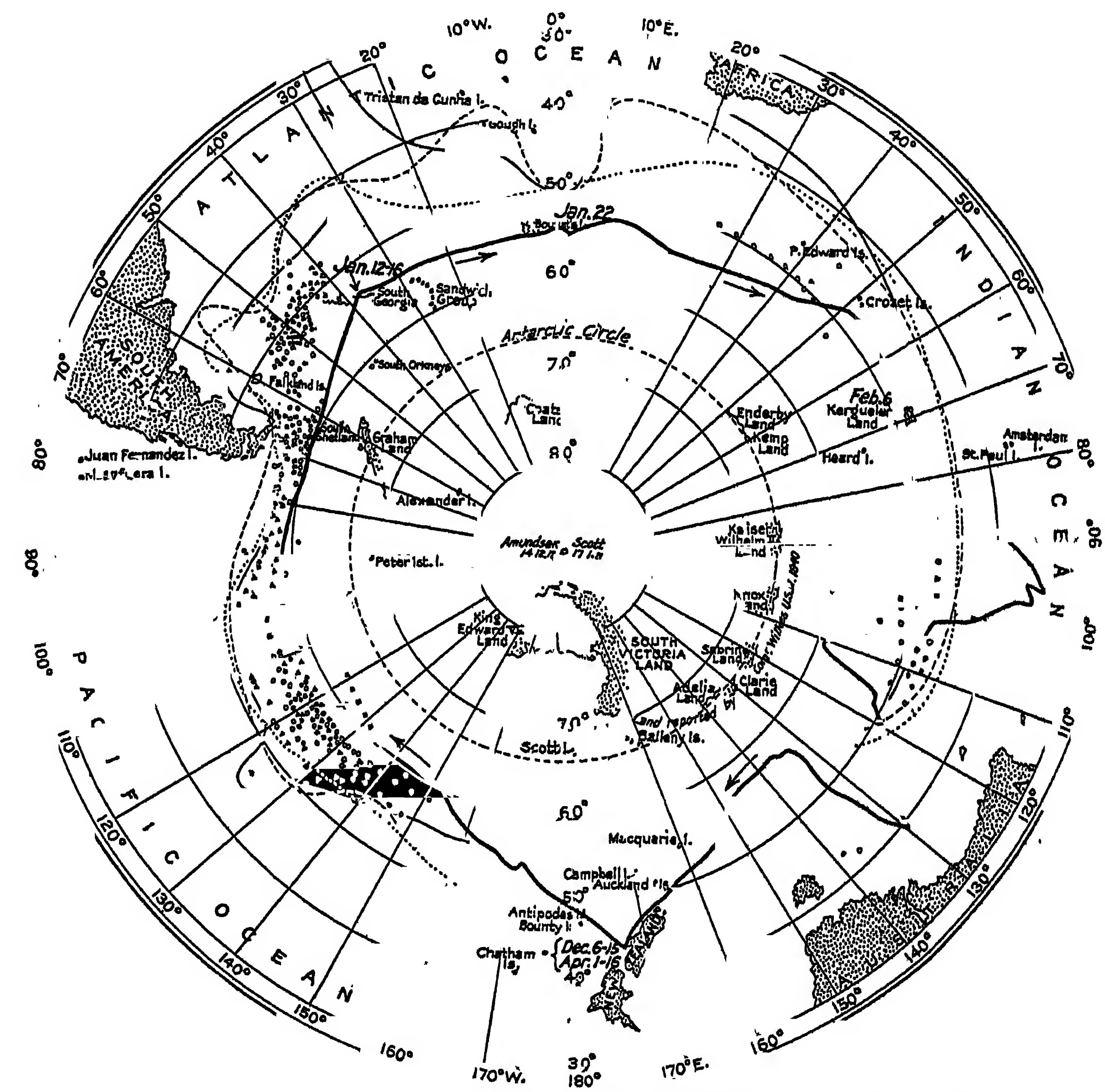


FIG. 1.—Track of the *Carnegie's* Sub-Antarctic Cruise, December 6, 1915 to April 1, 1916.

heavy clouds and squalls hanging over the island. Observations were carried out as usual during the passage. No magnetic-declination observations were obtained on May 30 and June 4 on account of clouds. Considerable lightning and thunder attended the squally weather. The new gooseneck on the upper topsail yard carried away on May 27, and was replaced with the extra one ordered at Lyttelton. The engine was operated to get offshore when leaving Lyttelton, to clear Savage Island during a calm on June 4, and to enter the harbor of Pago Pago on June 7. The time of passage was 22 days, with a daily run of 118 miles, for a total of 2,595 miles.

The shore observations having been completed, the *Carnegie* left Pago Pago on June 19, under her own power. The engine operated well, taking the vessel out against a stiff head trade-wind. The wind was too strong outside to allow making to windward of Tutuila, so the *Carnegie* went around the west end. The Union Group was weathered, but the wind broke off to the north of east, compelling the vessel to go to leeward of the main Phœnix Group. The wind held north of east, forcing the *Carnegie* considerably to the westward of the route planned; however, the crossings with previous tracks were made at the points desired. No storms or calms were encountered. The hot weather was very trying, but the party, with two or three exceptions, kept well. Magnetic declinations were obtained twice daily, with two exceptions. The average difference, without regard to sign, between the results obtained by the two observers at the collimating compass was 3′ for the 51 determinations. This affords some evidence as to the character of the weather and conditions encountered. Port Apra, Guam, was reached on Monday, July 17, 1916. The total run from Pago Pago was 3,987 miles, giving a daily average of 147 miles for the 27-day trip.

At Port Apra connection was made with the *Galilee* observations of 1907 and extensive intercomparisons of all instruments were made (see Pl. 4, Fig. 2). The *Carnegie* sailed from Port Apra on August 7, bound for San Francisco. The track followed was arranged to cross as frequently as possible the previous tracks of the *Galilee* and the *Carnegie*, and to obtain additional magnetic data in regions where most needed. For 7 days continuous heavy gales were encountered from the southwest, making it necessary to heave to for 2 days in succession, August 9 and 10. The vessel was thus driven northward and compelled to follow very closely the track of the *Galilee* from Guam to Japan, up to the point where the many tracks intersect (see Pl. 7). This was the worst spell of bad weather the *Carnegie* had thus far encountered. After August 17, moderate weather was experienced. There was considerable fog and cloudiness, but, with 4 exceptions, observations for declination were obtained daily. The engine was operated frequently, for a total of 90 hours, during calms and for swinging ship. On August 26, the vessel was swung for intensity and inclination observations, both helms. On August 27, a declination swing was started, but after 5 headings had been completed clouds prevented further observations. Fog was recorded on 12 days and rain or mist on 34 days.

On September 20, the *Carnegie* was becalmed off the coast of California, so the engine was operated, and after a 24-hour run San Francisco was reached on September 21. Fortunately, Point Reyes was sighted at 1 o'clock in the morning before the fog closed down. Creeping through the fog until the light vessel was heard, a pilot was taken aboard, and the *Carnegie* made the entrance into the harbor through the fog under her own power. The total distance run from Guam was 5,937 miles, the time of passage being 46 days, and the average daily run 129 miles. The chronometers were found in error only 8^{s}7.

After a stay at San Francisco of 5 weeks, during which shore observations and instrumental comparisons were made and the vessel was overhauled and outfitted, the *Carnegie* left this port November 1, 1916, bound for Easter Island. Light and variable

winds were encountered until the vessel reached the northeast trade-wind region. In the calm belt near the equator, between the northeast and the southeast trades, continuous light airs from the south to southwest caused a delay of over 2 weeks and forced the vessel far to eastward of her intended route. The remainder of the voyage was made under good conditions and Easter Island was reached December 24, 1916.

The stop at Easter Island was made in order to obtain magnetic data regarding secular changes, to secure a supply of fresh water, and to break the monotony of the long voyage from San Francisco to Buenos Aires. A magnetic station was established and a 24-hour series of declination readings was obtained. The party visited various points of interest on the island and obtained some valuable photographs of the large statues (see Pl. 5, Figs. 1, 2, 3, 4, and 6) for which the island is particularly noted.

After taking on board a small supply of fresh water and provisions, the vessel sailed January 2, 1917, for Buenos Aires. After leaving Easter Island adverse winds prevented the vessel from entering, as had been planned, the unsurveyed area to the northeast. On January 19, 1917, Gambier Islands were passed. As no stop was contemplated a small barrel, containing an abstract of all scientific results to date, was set adrift about one-half mile off the southeast entrance to Manga Reva Harbor.

Between January 22 and January 27 long and severe gales from the east to southeast were encountered. They were followed by 2 weeks of variable winds and weather, head-winds alternating with calms. When the vessel finally entered the region of the strong westerly winds, rapid progress was made toward Cape Horn.

On February 16 the Diego Ramirez Islands were sighted as expected and Cape Horn was passed the next morning. In the vicinity of Cape Horn the weather varied rapidly from one extreme to the other. The afternoon of February 16 was rainy and stormy, with a heavy gale from the northwest, but the evening was beautifully clear and almost calm. February 17 saw a repetition of the same change, the stormy weather ending early in the forenoon and the remainder of the day being clear and affording a fine view of Cape Horn and Tierra del Fuego. Owing to variable and adverse winds some difficulty was experienced in weathering Staten Island and also the Falkland Islands later. The vessel passed to the westward of the latter group in order to avoid the icebergs and rough seas to the eastward.

On March 1, 1917, the Recalada lightship at the mouth of the River Plate was passed. After taking on the pilot the engine was started and the *Carnegie* went up the river under her own power, reaching Buenos Aires next morning, March 2, 1917.

As usual, observations for magnetic intensity and inclination at sea were made daily, regardless of conditions of sea or weather. Magnetic-declination results were obtained every day but 4, which were too cloudy for these observations.

Tracks of the *Galilee* were crossed 11 times and the *Carnegie's* tracks of former cruises were crossed 7 times, thus affording several opportunities for the determination of the annual changes in the magnetic elements for the regions covered. The total distance sailed was 14,774 miles and the daily average for the 112 days at sea was 132 miles.

Shore observations and instrumental comparisons were made at the Argentine Magnetic Observatory located at Pilar (see Pl. 4, Fig. 6). Comparisons had previously been made at Pilar in 1911 during the first visit of the *Carnegie* and again by Observer H. F. Johnston in 1913, so that the correlation of the Argentine magnetic work with that of the Department has now been controlled 3 times.

On account of the war it was considered best to detain the *Carnegie* at Buenos Aires (see Pl. 1, Fig. 2). The ocean work of Cruise IV was brought to a conclusion and members of the party were assigned to other duties. Observer Jones was instructed to proceed to Lima, Peru, where he joined Mr. Fleming's party and was assigned to land work. Observers A. D. Power and L. L. Tanguy were assigned to land work in Argentina, viz,

to reoccupy certain magnetic stations established by the Argentine Government. Mr. George O. Wiggin, director of the Argentine Meteorological Service, assisted the *Carnegie* party in many ways and greatly facilitated the work in Argentina. Through his efforts passes over all the railway and steamship lines were given to each member of the party, and free entry for all the scientific instruments was granted by the customs department. At the solicitation of the American ambassador at Buenos Aires, the Argentine government extended port facilities and wharfage without charge to the *Carnegie* during her stay in port. The Department takes this opportunity to express its thanks to the government and people of Argentina for the many courtesies extended.

On May 29, 1917, Captain J. P. Ault, having been in command of the *Carnegie* for 3 years, was instructed by cable to return to Washington via Valparaiso for conference and assignment to shore duty. After completing all arrangements for turning over the command of the *Carnegie* to Dr. H. M. W. Edmonds, who had been second-in-command for 3 years, Captain Ault left Buenos Aires June 10 for Washington, where he arrived July 25.

The ship's personnel during Cruise IV was as follows: J. P. Ault, magnetician and master of the vessel; H. M. W. Edmonds, magnetician and surgeon, and second-in-command; H. F. Johnston (until April 1916, when he was assigned to land work), I. A. Luke (until October 1916, when he resigned), H. E. Sawyer (from April 1915 to December 1915, when he was assigned to land work), F. C. Loring (from December 1915 to October 1916, when he resigned), Bradley Jones (from April 1916), A. D. Power (from October 1916), L. L. Tanguy (from October 1916), observers; N. Meisenhelter, meteorological observer and clerk; R. P. Doran (until April 1916, when he resigned), and A. Beech (from April 1916), first watch-officers; M. G. R. Savary, engineer; Charles Heckendorn, mechanic; second and third watch-officers, 2 cooks, 8 seamen, and 2 cabin-boys; the ship's company always totaled 23 men. In addition, S. J. Mauchly remained with the vessel from Brooklyn to Panama to perfect the installation and operation of the newly-constructed atmospheric-electric instruments.

CRUISE V, DECEMBER 1917 TO JUNE 1918.

After the completion of Cruise IV the *Carnegie* was detained at Buenos Aires for over 9 months on account of the war. In October 1917 preparations were made to start the vessel on her homeward cruise from Buenos Aires to an Atlantic port by way of Cape Horn, the Pacific Ocean, and the Panama Canal. This cruise, designated Cruise V, began at Buenos Aires December 4, 1917.

The passage around Cape Horn to Talcahuano, Chile, was made in the short time of 38 days, arrival at the latter port occurring January 11, 1918. Although the usual stormy weather and heavy seas were encountered off Cape Horn, the winds usually drew from favorable directions. The daily average for the 38 days at sea was 102 nautical miles, the total run having been 3,863 miles, and the usual daily program of magnetic and other work was carried out without serious interruption.

After a stay of 12 days at Talcahuano, during which time the C. I. W. magnetic stations at Coronel and at Concepcion were reoccupied, the *Carnegie* sailed again on January 23, 1918, for Callao, Peru. After a large detour to the westward to fill in unsurveyed areas, the vessel arrived at Callao February 22, 1918, having made a highly successful trip of 30 days.

During the stay of over one month at Callao, a complete program of intercomparisons of instruments was carried out at a former C. I. W. station at Lima (see Pl. 4, Fig. 5). On March 29, 1918, the vessel set sail for Balboa, Canal Zone, arriving there April 24, 1918, after another detour to the westward to cover unsurveyed regions. On May 2, 1918, the *Carnegie* for the second time passed through the Panama Canal, this time from the Pacific to the Atlantic.

After a stay of 9 days at Cristobal, during which an intercomparison of instruments was again made, the *Carnegie* started out on the final part of her journey homeward on May 11, 1918. Owing to light winds and adverse currents some difficulty was experienced in clearing the coast of Panama. Conditions were also unfavorable for making the route called for to the eastward through the Caribbean Sea, so that it was necessary to set the course westward and return through the Gulf of Mexico and the Straits of Florida. On June 4, 1918, the vessel arrived at Newport News.

On June 8, 1918, the *Carnegie* left Newport News for Washington, where she arrived June 10, 1918, after spending a day in swinging-ship observations in Chesapeake Bay. Declination observations were also made in the bay and in the Potomac River. The trip from Old Point Comfort to Washington was made under the vessel's own power. Thus, after an absence of nearly three and one-half years, the *Carnegie* was once more in a home port on the Atlantic coast.

During Cruise V, the *Carnegie* traveled over 13,195 miles of ocean, and the daily average for the 122 days at sea was 108 miles. Tracks of former cruises by this same vessel were crossed 10 times and *Galilee* tracks were crossed 3 times, thus furnishing further valuable information regarding secular variation.

As usual, observations for magnetic intensity and inclination at sea were made daily, regardless of sea and weather. Magnetic-declination results were obtained every day but 4, which were too cloudy for these observations. The atmospheric-electric observations were continued throughout the cruise.

The ship's personnel during November 1917 to the close of Cruise V in June 1918 was as follows: Dr. H. M. W. Edmonds, magnetician and surgeon, and master of the vessel; A. D. Power, magnetician and second-in-command; B. Jones, L. L. Tanguy, and J. M. McFadden, observers; W. E. Scott, stenographer-recorder (N. Meisenhelter resigned as stenographer-recorder in September, having been continuously on board the *Carnegie* for five and one-half years); A. Beech, first watch-officer; M. G. R. Savary, engineer; L. Larsen and A. Erickson, second and third watch-officers, respectively; C. Heckendorn, mechanic; 8 seamen, 2 cooks, and 2 cabin-boys; the complete personnel at any one time thus consisted of 23 persons.

CRUISE VI, OCTOBER 1919 TO NOVEMBER 1921.

At the conclusion of Cruise V, June 30, 1918, the ocean-survey work was discontinued for the remaining period of the war. Dr. H. M. W. Edmonds continued in command of the *Carnegie* in Washington through December 1918 and had general supervision of the overhauling and dismantling of equipment and instruments. On December 31 he was relieved of command to take charge of and to prepare for the important work of acquiring a site and constructing the proposed observatory in Peru.

Mr. J. P. Ault resumed command of the *Carnegie* on January 1, 1919, and took up the general overhauling, repairing, and outfitting of the vessel for the resumption of the ocean-survey work. A cruise of 2 years was planned to start in August 1919, as it was expected that the repairs and alterations would then be completed. The unsurveyed regions in the South Atlantic and Indian oceans were to be covered and the return made through the Pacific Ocean and Panama Canal to Washington. The route was planned to obtain a large number of secular-variation observations, and included, as finally arranged, calls at the following ports: Dakar, West Africa; Buenos Aires, Argentina; Jamestown, St. Helena Island; Cape Town, South Africa; Colombo, Ceylon; Fremantle, Australia; Lyttelton, New Zealand; Papeete, Tahiti, Society Islands; San Francisco; Honolulu, Territory of Hawaii; Pago Pago and Apia, Samoa; Rarotonga, Cook Islands; Balboa, Canal Zone; and return to Washington. Short stops were made also at Fanning Island and at Penrhyn and Manihiki islands, Cook Islands.

Early in 1919 it was decided to convert the *Carnegie's* engine to operate on gasoline instead of on producer gas. This change seemed desirable because gasoline can now be secured in all frequented ports of the world and because of the increase in efficiency and reliability of operation resulting from the use of gasoline instead of producer gas. In accordance with this plan, early in March 1919, the engine was shipped to Jersey City, where the remodeling was carried out by the James Craig Engine and Machine Works, the builders of the engine.

On April 18, 1919, the *Carnegie* left Washington under tow and arrived at Baltimore the following day. The vessel was overhauled and extensive repairs and alterations were undertaken under the direction of the Spedden Shipbuilding Company of Baltimore. The vessel was hauled out on Booz Brothers' marine railway May 13, 1919, and was resheathed with yellow metal and copper. This work was completed May 22, but upon attempting to haul the vessel down into the water again the cradle of the marine railway left the track and could not be moved (see Pl. 2, Figs. 1 and 3). Special launching ways were constructed, the careful planning and building of which extended over a period of 3 months, as practically all the work had to be done by divers. Every precaution was taken to insure the safety of the vessel during these operations. After numerous delays, the vessel was finally afloat again on August 21.

The *Carnegie* then returned to the Spedden Shipbuilding Company, where the remodeled engine was installed. For the storage of the gasoline, two copper tanks, each 6 feet in diameter and 10 feet long, were installed in the former producer room. Each tank carries 2,100 gallons of gasoline. Every care was taken in the construction of the tanks and in the installation of the entire power plant to insure safety in the storage and use of this fuel.

The installation of electric storage-battery for lighting and low power uses was an important addition. All fittings and fixtures were made of nonmagnetic material wherever possible, and twisted cable was used for the circuits. The 1-kilowatt, 40-volt generator, which was used to charge the storage-battery, was mounted in the after end of the engine-room, as far as possible from the positions of the observing instruments. This generator was operated by the 6-horsepower gasoline engine at times when magnetic work was not in progress. The 1-kilowatt generator proved too small for the work required and was replaced in March 1921 by a 2-kilowatt generator when the vessel was in San Francisco.

The delays in the completion of the gasoline tanks and in getting the *Carnegie* off the marine railway compelled a postponement of the sailing date from Washington until October 9.

Sailing from Washington October 9, 1919, the *Carnegie* proceeded down the Potomac to Chesapeake Bay, where the usual "swinging-ship" operations were carried out October 11. The vessel then proceeded to Solomons Island, where simultaneous observations of the potential gradient of atmospheric electricty were carried out on board and on shore with the vessel's sails in the various positions occupied during observations at sea. Here the Director of the Department joined the vessel for a final inspection. Upon the completion of the atmospheric-electric work, the *Carnegie* sailed for Old Point Comfort, where the Director bade farewell to the party. Mr. J. A. Fleming, then chief of the Magnetic Survey Division, and Dr. S. J. Mauchly, chief of the Section of Terrestrial Electricity, left the vessel to return to Washington after all matters in their respective charges had been arranged.

After a few days' delay at Old Point Comfort, during which a steward was signed on and 7 seamen were replaced, the *Carnegie* finally sailed from Hampton Roads, bound for Dakar, Senegal, October 19, 1919.

Soon after leaving Old Point Comfort the vessel encountered the usual Gulf-Stream weather, consisting of heavy winds from various quarters, accompanied by rain-squalls and wet weather. Similar weather continued all the way to Dakar with only a few pleasant days intervening. Two heavy storms were encountered but no damage was done to the vessel. Upon approach to the African coast, the usual northeast trade-wind was replaced by winds from the southwest to southeast, making it necessary to keep well to the eastward in making the approach to Dakar. During the 4 days before arrival at Dakar heavy easterly winds, the harmattan, blew fine sand from the African desert, and moisture forming about the dust-particles developed into a fog which obscured the sun while below 10° to 15° of altitude. At the same time the horizon was nowhere more than one-half mile distant, which made navigation extremely uncertain and the approach to land particularly hazardous. Altitudes of the sun were measured from a position as near the sea-surface as possible and were then corrected for an estimated distance of the horizon. In spite of these uncertain conditions, the landfall was made as expected, and after standing off and on for 36 hours the *Carnegie* entered the harbor of Dakar under her own power when the haze lifted for a few hours November 22, 1919.

On account of the presence of bubonic plague in Dakar, the *Carnegie* remained in that port only long enough to take on water and supplies, sailing for Buenos Aires November 26, 1919.

Fair winds for the first 3 days were followed by 10 days of calms and light variable winds, during which time it was necessary to operate the engine. After safely rounding Cape Palmas, Liberia, the southwest monsoon was encountered, and it continued to blow from December 9 to December 18 as the *Carnegie* sailed southeastward into the Gulf of Guinea. Two days later the vessel entered the region of the southeast trade-wind, and for 11 days the daily run averaged from 125 to 188 nautical miles with fine weather and under good sailing conditions.

After leaving the trade-wind region, about 10 days were spent in crossing the belt of calms, variable winds, and storms before the vessel entered the River Plate. On each of the two nights before reaching the river a heavy storm or "tempestura," from the westward occurred, with heavy rain and strong and shifting wind. Landfall was made with the aid of star observations during lightning flashes of the receding storm as they illuminated the horizon. Buenos Aires was reached January 19, 1920.

During the stay of 33 days at Buenos Aires the work and equipment of the vessel was inspected by Mr. Fleming for the Director, whose contemplated visit had to be abandoned because of pressing matters at Washington.

Various repairs were also carried out and the different magnetic instruments were intercompared on shore. Through the efforts of the American ambassador, the Argentine Government, as during previous visits of the *Carnegie*, extended various courtesies and privileges to the vessel during her stay at Buenos Aires. These courtesies and the facilities afforded by the Argentine customs officials were very much appreciated. Two watch-officers, 1 cook, the mechanic, 7 seamen, and the 2 mess-boys were replaced here. On February 21, 1920, the vessel left for St. Helena.

A week of moderate winds was followed by a heavy gale on February 28 as the vessel entered the region of the "roaring forties." For 48 hours the vessel ran before the storm at the rate of 10 knots with only the goose-winged lower topsail set. She scudded in the heavy cross-sea, shipping wave after wave from stem to stern. As the vessel proceeded southward, the cold and disagreeable weather gave warning of the presence of ice. On March 3 and 4 four large icebergs were passed.

Gough Island was sighted March 8 and several very interesting hours were spent passing this lonely, uninhabited island of the South Atlantic. Large numbers of the

wandering and sooty albatross were present around the island, indicating this as one of their homes. Several specimens were caught and examined.

The latitude as given for Gough Island seems to be in error by 3'.4, our observations giving 40°15'.8 S., instead of 40°19'.2 S., as shown on British Admiralty chart No. 2228, for Penguin Islet.

St. Helena was reached March 27 after a remarkable trip of 35 days, during which the daily run averaged 151 miles. During the 7 days at St. Helena the Department's magnetic station at Longwood was reoccupied. Several trips over the island were taken by the party, during which the various places of historic interest were visited. After fresh water and supplies were taken on board, the *Carnegie* sailed for Cape Town April 3.

After 3 days of sailing in the southeast trade-wind, the region of variable winds and calms was entered. *Considerable lightning accompanied by heavy thunder was noted during some of the heavy squalls encountered in the middle of the South Atlantic far from land.* The region of the westerly winds and storms was reached April 11. Tristan da Cunha Island was sighted April 15.

The usual cycle of atmospheric-pressure changes with their corresponding storms and changes in the direction of the wind for these regions was experienced. With high pressure northerly winds blow, shifting to northwest and west as the pressure decreases. The more rapid the decrease the stronger the wind blows. At the lowest pressure-point the wind shifts to southwest and blows hard if the pressure increases rapidly, shifting to south and southeast as the pressure rises, finally jumping to northeast and north as the highest pressure-point is reached.

Cape Town Harbor was entered April 24 after 21 days at sea, during which the high average of 152 miles per day was made. Here the usual intercomparisons of instruments was made at the Department's former station near the Royal Observatory. Considerable repair work to the vessel was undertaken. The decks and outside of the vessel were recaulked, the two ranges were overhauled and rebuilt, and various repairs were made to the plumbing.

The people of Cape Town made the stay of the party very pleasant by their generous hospitality and by the many courtesies extended. The port authorities granted all privileges to the *Carnegie* during her stay, and various exemptions were made by the government officials in the matter of payment of towboat charges, customs dues, and immigration regulations. Opportunity is here taken to make grateful acknowledgment of these many courtesies.

On May 20 the *Carnegie* sailed for Colombo, this port having been substituted for Aden in the revised route instructions. During this trip 4 strong gales were encountered and heavy winds prevailed in general. The vessel spent 19 days in the region of the "westerlies," after which the southeast trade-wind was picked up with a few hours of calm intervening. After one week in the southeast trades, the southwest monsoon was encountered, and this wind continued until our arrival at Colombo. *The route extended up into the Arabian Sea in order to cross the Carnegie's 1911 track and and to relocate the agonic line.* While crossing this line 6 declination determinations were made in 25 hours with perhaps more than the usual accuracy in spite of the gale which was blowing.

At midnight June 26 the light on Minikoi Island was sighted as expected. Eastward of Minikoi the monsoon was very light, so that the *Carnegie* did not reach Colombo until the morning of June 30, after being hove to off the port all night. The distance covered from Cape Town to Colombo was 6,665 miles, giving a high average run of 163.4 miles for the trip of 40.8 days.

The trip from Cape Town was unusual in that declination observations were made daily in spite of the unfavorable weather conditions. Rain or precipitation of some

kind occurred on 29 out of 40 days. On but 6 days were declination observations made only once, on 29 days they were made twice, on 3 days they were made 3 times, and on 1 day they were made four times, when relocating the agonic line. The chart errors in declination for the southern part of the Indian Ocean averaged over 1 degree, sometimes reaching 2.5 degrees. In the northern part they were less than 0.5 degree.

At Colombo an extended program of intercomparisons of instruments was carried out at the Department's station in the grounds of the Colombo Observatory. The use of the observatory was freely offered by the surveyor-general and by the director of the observatory, Mr. Bamford; the ready cooperation thus received and courtesies shown by the various officials greatly facilitated our work.

The vessel left Colombo July 24, the course being set for a point somewhat southwest of Java and thence generally southward to about latitude 33° south and longitude 85° east. Thence the vessel followed a track generally to the east and arrived at Fremantle on August 31. For 9 days during this part of the cruise continuous calm was experienced and the auxiliary power had to be used for a distance of 800 miles to get through the belt. Declination observations were made at over 50 stations.

The complete program of intercomparisons of ships' instruments was carried out at Cottesloe, near Fremantle. The land instruments aboard the *Carnegie* were also compared with the standards at the Watheroo Magnetic Observatory of the Department.

Upon the completion of the work at Cottesloe and at Watheroo, the *Carnegie* left Fremantle October 1 and after considerable difficulty in clearing Cape Leeuwin on account of heavy storms from the westward, followed a course to the south of Australia, reaching 50° south latitude and about 140° east longitude. Thence the course was shaped to the eastward for Lyttelton. On October 12 the *Carnegie* was within 1 mile of the charted position of the Royal Company Islands, 50° 20′ south and 142° 50′ east. Nothing was in sight for a radius of 40 miles with very good visibility. The *Carnegie* sailed eastward all day at about 50° 20′ south latitude and there were no signs of land. These islands have been searched for unsuccessfully by several navigators and have been omitted from nearly all the present navigation charts. Heavy northwest winds and seas prevented making Cook Strait, and Lyttelton was reached from the southward October 20. The total distance was 3,157 miles, making the daily average of 160 miles for the 20 days at sea.

The series of comparisons between the standard instruments of the Christchurch Observatory and those of the *Carnegie* were satisfactorily completed early in November; Mr. H. F. Skey, director of the observatory, extended every courtesy and facility for this work and took an active part in the observations. The *Carnegie* was towed out to sea November 19 and proceeded under her own power until after clearing Banks Peninsula, when all sails were set. For 3 days the wind blew from the north, then shifted to the west and remained westerly for 4 days. The 180th meridian of longitude was crossed November 22 and that date was repeated.

No heavy storms were met, but moderate gales blew on November 22, November 27, December 1, and December 5. From December 1 to December 10 the wind blew steadily from the northwest, driving the vessel about 600 miles east of her course. On December 14, on entering the southeast trade-wind, course was set for Papeete, which was reached December 23.

The total distance sailed from Port Lyttelton to Papeete was 4,262 miles, which gives a daily average of 122 miles for the 35 days at sea. Magnetic observations were obtained at 54 stations for declination and at 33 stations for inclination and horizontal intensity. Complete determinations of the 5 atmospheric-electric elements (potential gradient, conductivity, ionic numbers, penetrating radiation, and radioactive content)

were made on 9 days; 4 elements were observed on 13 days; and three 24-hour series of diurnal-variation observations for the first three elements named were made.

Shore observations to obtain secular-variation data were made at the Department's station of 1916 at Point Fareute. Some special work was also done in connection with the atmospheric-electric instruments.

The *Carnegie* left Papeete Harbor on the afternoon of January 3, 1921, in the midst of a heavy tropical rain squall. Fortunately the wind held more from the east than from the north during the entire run from Papeete, so that Fanning Island was sighted at 10 o'clock on the morning of January 14 from a good bearing, after being hove to 60 miles east of the island during the previous night. The vessel arrived off Whaler's Anchorage at 1^h 25^m p.m., and after tacking back and forth for two and one-half hours, during which time cablegrams were dispatched, departure was taken for San Francisco. The old *Galilee* station is no longer available on account of the extension of buildings and electric wiring; observations could not be made ashore, owing to the necessity of sailing that evening.

As the vessel was now leaking more than usual, it was considered advisable to proceed to San Francisco to dock for examination. The course was kept somewhat eastward of the one planned, so that it passed through the western Hawaiian Islands at Laysan Island instead of beyond the Midway Islands. From Fanning Island to Laysan there was no calm belt and no evidence of a proper northeast trade-wind. The easterly wind blowing at Fanning Island continued until after passing Laysan Island, often blowing from south of east. Laysan Island was passed at a distance of 1 mile on January 25. The position of the landing-place near the group of buildings, from the observations made on board the *Carnegie,* is: latitude, 25° 46′.1 north; longitude, 171° 42′.7 west of Greenwich. This position depends upon a latitude observation on Venus simultaneously with a longitude observation on the Sun in the afternoon two and one-third hours before passing the island, and upon latitude and longitude observations from stars 3 hours later, taken 10 minutes after the last bearing was obtained on the island, at a distance of about 1⅛ miles. There was no evidence of a northerly or southerly current, and only 0.1 knot westerly set between the two observed positions. The longitude has been corrected for chronometer error determined after arrival at San Francisco. The position as given on the chart is 25° 42′.2 north, 171° 44′.1 west for the lighthouse, which should be near the landing-place as above. This shows the island to be 3.9 miles north of its charted position and 1.3 miles east. Soundings of 8 and 8.5 fathoms were obtained 1 mile off the southern end of the island, where, also numerous dark patches were noticed which seemed to indicate shallower water.

On January 28, in latitude 32° north, a northwesterly gale began which continued for 4 days and prevented making the desired northing. From February 1 to February 11 southerly winds and gales continued without interruption. Rough seas and consequent increase in leaking made it necessary to proceed under greatly reduced sail. Fine weather prevailed February 17, 18, and 19. A good landfall was made at 1 p. m., February 19, by bearings on Point Reyes and the Farallon Islands, and the anchorage in San Francisco Bay was reached at 10 o'clock the same evening.

Declination observations were made daily with the exception of 2 days. Unusually good weather was found near the California coast, so that declinations were obtained where previous cruises had failed to get them on account of clouds and fog.

The *Carnegie* arrived at San Francisco after 47.3 days at sea. The average daily run was 128.9 miles for the 6,099 miles traversed. Magnetic observations were obtained at 81 stations for declination and at 44 stations for inclination and horizontal intensity. Because of instrumental difficulties, the radioactive content was measured on 3 days only. The other four atmospheric-electric elements were observed on 21 days, and

diurnal-variation observations were attempted on 6 days, on 3 of which weather conditions prevented a complete series.

At San Francisco the vessel was dry-docked, and such general repairs as found necessary on examination were made. Because of the short cruise planned before the return to Washington, when the vessel probably would have to be opened up for careful examination and possibly might require extensive repairs before going out again, it was decided to copper-paint instead of resheathing the hull. The electric generator was replaced by a 2-kilowatt generator, in order to make more adequate provision for the experimental work. Cylinder 4 of the main engine, because of a serious crack that had developed early in 1920, was replaced by a new phosphor-bronze cylinder.

Advantage was taken of the delay occasioned by the repair work to obtain complete standardizations of the ship's magnetic instruments at a new station, Fort Scott; the old station on Goat Island was found no longer suitable. Complete intercomparisons between substandard magnetometer-inductor No. 26, which had been brought especially for this work from Washington by Mr. Fleming, and the ship's standard land instruments were also made at Fort Scott. The results showed that the corrections for the ship's equipment had remained nearly constant.

Dr. J. C. Merriam, President of the Institution, made a personal inspection of the *Carnegie* on March 24.

The chief of the Magnetic Survey Division (Mr. Fleming), representing the Director, made an inspection of the vessel during February 24 to March 7, while she was in San Francisco, and took up various urgent matters with Captain Ault relating to instruments, equipment, and future work.

Upon the completion of the other shore work, capacity determinations were made for the conductivity apparatus, the radioactive-content apparatus, the ionic-content apparatus, and the penetrating-radiation apparatus.

The repair work and other business matters being completed, the *Carnegie* left the dock at 4 p. m. March 28 and sailed direct for Honolulu. During the entire passage observing conditions were good and permitted declination observations twice every day, except on April 1, when cloudy weather prevented them. Winds were moderate to fresh and favorable all the way. As the Hawaiian Islands were approached, the wind became quite strong and a very heavy current from the south was found in Kaiwi Channel between Molokai and Oahu Islands. The vessel arrived off Honolulu Harbor early April 12 and was alongside the dock at 8^h40^m a. m.

The distance traversed was 2,222 miles, giving an average of 151 miles per day for the 14.7 days of the trip. Magnetic observations were obtained at 27 stations for declination and at 14 stations for inclination and horizontal intensity. Atmospheric-electric observations of the five elements were carried out on 3 days and of all elements except the radioactive content on 7 other days; 24-hour series diurnal-variation observations were made on 3 days.

The marked changes and improvements in the methods, instruments, and equipment provided for ocean observations since the cruise of the *Galilee* 16 years before were extremely gratifying. The *Galilee* made the passage from San Diego to Honolulu in 12 days during the year 1905, covering much the same region as the *Carnegie* covered in 1921. Thirteen stations were occupied then, as contrasted to 41 on the *Carnegie's* trip.

During the stay at Honolulu, a complete series of comparisons between the magnetic standards aboard the *Carnegie* and those at the Honolulu Magnetic Observatory of the United States Coast and Geodetic Survey was obtained. Additional capacity determinations were made for the ion counter, the radioactive apparatus, and the conductivity apparatus.

After completion of the comparisons at the Honolulu Magnetic Observatory, the *Carnegie* sailed April 28 and upon rounding the island of Oahu ran into the northeast trade-wind, which held until the parallel of 34° north latitude was reached. Westerly and northerly winds generally prevailed as the vessel sailed eastward along this parallel. On May 13 the northeast trade-wind was picked up again and then a southeasterly course was steered until May 21, when it was changed to a southwesterly one direct for the Samoan Islands. The *Carnegie* entered the region of the "doldrums" May 27 and left it May 29 with a light southeast wind which continued with variable force all the way to Pago Pago, but grew quite strong two days before the port was reached.

On June 12 a stop of a few hours was made at Penrhyn Island (see Pl. 5, Fig. 5), which is a typical coral atoll. The brief visit ashore was a welcome relaxation and enabled the party to secure some coconuts and Rarotonga oranges. A stop of a few hours was also made at Manihiki Island on June 15, and fresh fish, eggs, and coconuts obtained.

The Manua Islands were sighted early June 20, and by 6^h20^m on the same evening the vessel was moored to the buoy in Pago Pago Harbor. After setting up the rigging and replenishing stores, the *Carnegie* left Pago Pago in the afternoon of June 28 and arrived off Apia the following morning. The total distance to Apia was 5,994 miles, which makes an average of 111 miles per day for the 54 days of sailing.

Winds were usually quite favorable throughout the passage, though never very strong; no storms were encountered and observing conditions were excellent. Declination observations were made on every day but one, usually twice a day. The total number of stations was 96; inclination and horizontal-intensity observations were made at 48 stations. On May 31 the vessel was swung for declination observations under fairly good conditions, the maximum rolling being 5° to starboard and 8° to port, and the ranges in the results were no larger than the indicated error of observation, 5′ in the collimator results and 9′ in the deflector results.

After official calls on the American consul and on the governor, arrangements were made for the work to be undertaken at the Samoa Observatory. The comparison of standards at the Observatory with those of the *Carnegie* was begun June 30 after consultation with Mr. C. J. Westland, then in charge of the observatory, and with the former director, Dr. Angenheister, who left Apia July 2 to return to his native country. Plans regarding continuance of the work in atmospheric electricity and regarding the past work and methods were discussed with Dr. Angenheister and Mr. Westland. Upon cabled authority from the office, and since some of the observatory apparatus was in poor condition, certain appliances for atmospheric-electric work were transferred from the ship to Dr. H. M. W. Edmonds for use at the Apia Observatory. A magnetometer, typewriter, and other equipment were also left at the observatory for Dr. Edmonds' use.

For facilitating the comparisons at the Apia Observatory, two new outside stations were established (see Pl. 4, Fig. 8), as the outside pier heretofore used for intercomparison work was found to be constructed of magnetic material. All ship instruments were also standardized. With the cordial and effective cooperation of Mr. Westland and of Dr. Edmonds the large amount of observational work was satisfactorily completed and the *Carnegie* sailed for the Canal Zone July 25.

It was necessary to depart from the track originally planned in order to land Dr. Pemberton for medical treatment at Avarua, Rarotonga Island, and allow him to return home. The vessel left Rarotonga August 15 and arrived at Balboa October 7. The *Carnegie* tracks of earlier cruises were crossed 12 times and the *Galilee* track of 1908 was crossed once. These intersections (see Pl. 8) will yield important secular-variation data. A reversal of the usual currents was noted in the Gulf of Panama, the set being toward the south instead of to the north. Excellent results were obtained during the frequent

observations of diurnal variation in atmospheric electricity. The average daily run was 124 miles for the 72 days between Apia and Balboa.

Secular-variation observations were made at Colon and a new magnetic station was occupied at Old Panama City. After dry-docking at Balboa the *Carnegie* proceeded through the canal and set sail October 20 for Washington on the last passage of Cruise VI.

A favorable southeast wind enabled her to make excellent headway towards Windward Passage, through which she ran on October 25 and 26 in a calm. Gales, or strong winds, then prevailed to November 6, when Cape Henry was sighted early in the morning. At 11 a. m., November 6, the *Carnegie* put in at Old Point Comfort and about an hour later proceeded up Chesapeake Bay to "swing ship" the following day at the same place as in 1919. "Swing observations" were made for the magnetic elements November 7 and the reduction-factor for potential gradient was determined off Solomons Island the next day. The results of the "swing magnetic observations" verified the absence of any appreciable "deviation-corrections" at the observing places aboard the *Carnegie*. On November 9 the *Carnegie* left for Washington, came up the Potomac with engine running, and docked at Smith's wharf at 5^h30^m p. m., November 10. The total distance at sea was 1,975 miles, which was made in 17 days at an average daily speed of 116 miles

The Director joined the vessel at Balboa on October 12 for inspection of the work, and accompanied the party on the return cruise to Washington. Mr. R. R. Mills returned to the United States from the Canal Zone to resume his university studies. Dr. F. A. Franke was assigned to the ship's personnel at Balboa to take the place made vacant because of the illness of Dr. Pemberton.

The engine was operated very satisfactorily on many occasions throughout Cruise VI.

The total number of declination stations obtained during Cruise VI was 834, and the total number of horizontal-intensity and inclination stations was 439 for each element. The total distance covered from December 9, 1919, to November 11, 1921, was 64,118 nautical miles in 487 days at sea, making an average daily travel of 132 nautical miles. The average distribution of stations along the track of the cruise is very satisfactory, namely, one declination station for every 77 nautical miles, and one horizontal-intensity and inclination station for every 146 nautical miles. In addition to the magnetic work, atmospheric-electric observations were carried out regularly for 4 or 5 atmospheric-electric elements on each of 333 days, while diurnal-variation observations in atmospheric electricity were made on 36 days. In addition, roll-and-pitch records of ship's motion have been obtained frequently, and daily meteorological observations and various observations for determining geographic position have been made. Considerable time has been devoted to obtaining further data regarding performance of galvanometer and of earth inductor on board ship, as shown by the inductor observations, using the string galvanometer and the marine d'Arsonval galvanometer on alternate days; the work with the string galvanometer is not yet altogether satisfactory. Rock specimens were collected at ports of call for Dr. H. S. Washington's investigations at the Geophysical Laboratory.

The ship's personnel during Cruise VI was as follows: Dr. Louis A. Bauer, Director (October 12 to November 10, 1921); J. P. Ault, chief of the Section of Ocean Work, in command; H. F. Johnston, magnetician, second in command; Russell Pemberton, surgeon (until August 14, 1921); A. Thomson, H. R. Grummann, and R. R. Mills (until October 12, 1921), observers; F. A. Franke, surgeon (from October 12, 1921); A. Erickson, first watch-officer, C. E. Leyer, engineer; L. Larsen, second watch-officer (from February, 1920); F. Lyngdorf, steward; third watch-officer; 1 cook; 1 mechanic; 8 seamen; 2 cabin-boys; in all, 23 men.

The continued success of the ocean-survey work has been made possible in no small measure by the privileges and many courtesies extended the *Carnegie* and her staff by governmental and harbor authorities, as well as by men of science, at every port of call.

MAGNETIC INSTRUMENTS USED IN THE CARNEGIE WORK.

The magnetic instruments used on board the *Carnegie* during cruises IV, V, and VI have been practically the same as those used during cruises III and IV and described in Volume III, Researches of the Department of Terrestrial Magnetism, pages 177–203. Some mechanical improvements have been made from time to time and repairs have been made as noted under each instrument.

MARINE COLLIMATING-COMPASS FOR MAGNETIC DECLINATION.

A detailed description of this instrument and a discussion of the theory and methods of observation will be found in Volume III (pp. 177–190). In practice it has been found more expeditious and less troublesome, to compute, by the rigorous formula, the value of A, the corrected magnetic azimuth of the Sun or star, rather than to use the correction tables as given in Volume III (pp. 182 and 183). This was especially true when the Sun or star was observed at a high altitude, which was often the case, particularly in stormy latitudes.

The methods of observation have remained the same, except that a "set" consists of only 10 readings of the scale and the time is noted only at the beginning and end of each set.

The constants A_c, v, and m have been redetermined for cruises IV, V, and VI from a discussion of all comparison observations at shore stations during these cruises.

TABLE 1.—*Observed and Adjusted Values of A_c.*

Date	Station	Wt.[1]	Observed values of A_c for scale S	W	N	E	Adjusted values of A_c for scale S	W	N	E
			°	°	°	°	°	°	°	°
1915										
Feb. 15, 16...	Washington....	3	359.78	89.65	179.87	269.96	359.780	89.680	179.860	269.940
Apr. 6.......	Colon.........	2	359.84	89.72	179.91	269.92	359.812	89.712	179.892	269.972
June 2, 16, 17.	Honolulu......	4	359.83	89.69	179.88	269.96	359.805	89.705	179.885	269.965
July 27.......	Dutch Harbor..	1	359.76	89.66	179.84	269.93	359.762	89.662	179.842	269.922
Nov. 19, 20...	Christchurch...	3	359.84	89.71	179.88	270.00	359.823	89.723	179.903	269.983
1916										
Apr. 20......	Christchurch...	2	359.79	89.66	179.86	269.96	359.783	89.683	179.863	269.943
July 29.......	Guam.........	2	359.76	89.67	179.86	269.95	359.775	89.675	179.855	269.935
Oct. 13.......	Goat Island....	2	359.77	89.70	179.85	269.96	359.785	89.685	179.865	269.945
1917										
Mar. 16, 28...	Pilar..........	2	359.80	89.76	179.90	269.98	359.825	89.725	179.905	269.985
Nov. 5.......	Do.........	3	359.80	89.69	179.87	269.95	359.792	89.692	179.872	269.952
1918										
Mar. 12......	Lima.........	3	359.76	89.70	179.87	269.96	359.787	89.687	179.867	269.947
July 2, 3.....	Washington....	2	359.73	89.67	179.81	269.91	359.745	89.645	179.825	269.905
1919										
Aug. 15......	Do.........	2	359.68	89.62	179.86	269.98	359.750	89.650	179.830	269.910
1920										
July 15, 19...	Colombo......	2	359.77	89.67	179.88	269.96	359.785	89.685	179.865	269.945
Sept. 21......	Fremantle.....	2	359.80	89.70	179.90	270.00	359.815	89.715	179.895	269.975
1921										
Mar. 15......	San Francisco..	2	359.76	89.66	179.84	269.96	359.770	89.670	179.850	269.930
Dec. 3, 5.....	Washington....	2	359.79	89.68	179.87	269.97	359.792	89.692	179.872	269.952
	Weighted means						359.79	89.69	179.87	269.95

[1] Observed values were weighted according to the number of determinations at each station.

In Table 1 are tabulated the observed values of A_c during cruises IV, V, and VI of the *Carnegie* and the adjusted values resulting from taking $R^{I}=90°.08$, $R^{II}=90°.18$, $R^{III}=89°.90$, and $R^{IV}=89°.84$. These values of R^{I}, R^{II}, R^{III}, and R^{IV} are the mean values of determinations made, by using two theodolites, at Washington in February 1915, August 1919, and May 1922. Throughout cruises IV, V, and VI the observers constantly drummed the instrument during the observations to overcome the frictional resistance

of the pivot and the instrument was sheltered from the direct rays of the Sun. Owing to the very satisfactory behavior of this instrument and to the small changes in the constants, determination of the values of A_e was not made so frequently during Cruise VI in order to reduce the time used in comparing instruments at the shore stations.

The value v of one scale-division is obtained from the theodolite pointings on the various divisions. The following are the final mean values of v as determined at Washington in February 1915, August 1919, and December 1921, at Honolulu in June 1915, and at Christchurch in November 1915, and adopted for cruises IV, V, and VI:

Scale	S	W	N	E
v	0°97	1°00	1°00	1°02

These values are so near 1 degree that for the sea calculations they were considered as unity, thus saving one step in the preliminary computations. The final values of the declination as published in this volume have been corrected for the above divergence from unity in the values of v for the south and east scales.

TABLE 2.—*Values of the scale inclinations, m.*

Date	Station	m_{sn} Obs'd	m_{sn} Adjusted	m_{sn} Comp'd	m_{sn} A–C	m_w
		°	°	°	°	°
1915						
Feb. 15, 16	Washington	+0.72	+0.72	+0.71	+0.01	+0.14
Apr. 6	Colon	+0.33	+0.33	+0.31	+0.02	+0.10
June 2, 16, 17	Honolulu	+0.32	+0.33	+0.32	+0.01	+0.17
July 27	Dutch Harbor	+0.65	+0.63	+0.62	+0.01	+0.14
Nov. 19, 20	Christchurch	−0.67	−0.70	−0.69	−0.01	+0.14
1916						
Apr. 20	Do	−0.66	−0.69	−0.69	0.00	+0.11
July 29	Guam	+0.12	+0.11	+0.12	−0.01	+0.09
Oct. 13	Goat Island	+0.61	+0.61	+0.61	0.00	+0.10
1917						
Mar. 16, 28	Pilar	−0.11	−0.14	−0.14	0.00	+0.12
	Mean for Cruise IV					+0.12
Nov. 5	Pilar	−0.14	−0.15	−0.14	−0.01	+0.10
1918						
Mar. 12	Lima	+0.02	+0.01	+0.01	0.00	+0.06
July 2, 3	Washington	+0.71	+0.70	+0.71	−0.01	+0.06
	Mean for Cruise V					+0.07
1919						
Aug. 15	Washington	+0.72	+0.73	+0.71	+0.02	+0.05
1920						
July 15, 19	Colombo	−0.03	−0.04	−0.02	−0.02	+0.01
Sept. 21	Fremantle	−0.60	−0.63	−0.65	+0.02	0.00
1921						
Mar. 15	San Francisco	+0.60	+0.60	+0.61	−0.01	−0.09
Dec. 3, 5	Washington	+0.67	+0.67	+0.71	−0.04	−0.21
1922						
May 11	Do					−0.19

Cruise VI Date[1]	Cruise VI m_w
	°
1919	
Oct. 9	+0.06
Nov. 14	+0.05
Dec. 21	+0.04
1920	
Jan. 26	+0.03
Mar. 3	+0.02
Mar. 28	+0.01
May 15	0.00
June 21	−0.01
July 28	−0.02
Sept. 2	−0.03
Oct. 9	−0.04
Nov. 14	−0.05
Dec. 21	−0.06
1921	
Jan. 26	−0.07
Mar. 4	−0.08
Mar. 29	−0.09
May 16	−0.10
June 21	−0.11
July 29	−0.12
Sept. 2	−0.13
Oct. 9	−0.14
Nov. 14	−0.15

[1]Value applies up to and including date given.

From simultaneous measurements made at Washington in 1915, 1918, 1919, 1921, and 1922, the following relations were established:

$$m_s + m_n = +0°18 \qquad m_e + m_w = 0°00$$

The values of m_e and m_w were constant for cruises IV and V. During Cruise VI the value of m_e changed gradually from $-0°07$ to $+0°16$, m_w going through a similar change

of opposite sign. This probably was due to some inequality in the change of magnetization of the magnets in the magnet system of the instrument.

The adjustment for cruises IV, V, and VI of the values of m_s and m_n, which change with varying values of the vertical component Z of the Earth's magnetic field, gives

$$m_s = +0^\circ.01 + 1^\circ.26\ Z$$

and from the relation $m_s + m_n = +0^\circ.18$ there results

$$m_n = +0^\circ.17 - 1^\circ.26\ Z$$

The observed values of m_{sn} and the values adjusted and computed from the above are given, together with their differences, in Table 2. The values of m_w, after having been adjusted to the condition of $m_e + m_w = 0^\circ.00$, are likewise found in the table; the mean values indicated were used for cruises IV and V while for Cruise VI those computed from a least-square adjustment, given in the last column, were used. The corresponding values of m_e for all three cruises are given by the relation

$$m_w + m_e = 0^\circ.00.$$

SEA DEFLECTOR FOR MAGNETIC HORIZONTAL INTENSITY AND DECLINATION.

Declination Observations.

The sea deflector has continued to be used as a check upon the declination results with the marine collimating-compass. A description of sea deflector 4, which was used on Cruise IV as far as San Francisco, and of sea deflector 5, which was used during the remainder of Cruise IV and throughout cruises V and VI, will be found on pages 192–194, Volume III. The "bright-line" method was found to be preferable to the "shadow" method and was used exclusively throughout all three cruises.

Scheme of Horizontal-Intensity Observations.

The same general scheme previously used has been followed during cruises IV, V, and VI. In order to avoid any drag of the magnet card, the time allowed at the beginning of observation for each magnet (not distance) after the magnet is in position, as also between each reversal of sights and bowl, has been increased from 2 full minutes to 3 minutes; 1.5 minutes is allowed between all other positions.

SEA DIP-CIRCLE FOR INCLINATION AND TOTAL INTENSITY.

Sea dip-circle 189 was used throughout cruises IV, V, and VI, except in March 1915, when 204 was used. Considerable difficulty was experienced with 204 in placing and removing the needles. One needle was broken at sea and another was broken during comparison observations at Colon. Circle 189 was then used and no difficulty was experienced until one pivot of needle 3 was broken at sea on November 27, 1920. Up to that time the same 4 needles (needles 1 and 2 for regular dip and needles 3 and 4 for deflected and loaded dip) had been used since leaving Colon in 1915. Needles 11 and 12 were used in place of needles 3 and 4 subsequent to November 27, 1920, to the close of Cruise VI.

MARINE EARTH-INDUCTOR FOR INCLINATION.

Marine earth-inductor 3 with moving-coil galvanometer as described in Volume III (pp. 196–199), continued in use throughout cruises IV and V. The absolute accuracy of observed values of inclination using this combination continued to depend largely upon the performance of the galvanometer. The balancing nuts on the coil should be loose on their screws to permit ready adjustment, and the consequence was that any jar on the ship near the galvanometer house, such as knocking of rudder stock in its housing, flapping of mainsail, or removing of hatchways, threw the coil out of balance.

At the beginning of Cruise VI so much difficulty was encountered in balancing the coils that observations with the earth-inductor were omitted at sea until the new string galvanometer was completed and ready for use in August 1920. A detailed description of this instrument is given below. A special slip-ring coil (see Pl. 3, Fig. 3) was constructed by the Department to be fitted in earth-inductor 3 for use with the new string galvanometer. Beginning at San Francisco in March 1921, a new coil, constructed by the Department, was used in the moving-coil galvanometer, earth-inductor 7 (see Pl. 3, Fig. 1) now being used with this galvanometer. On alternate days, observations were made with the string galvanometer and earth-inductor 3 and with the moving-coil galvanometer and earth-inductor 7, to test the relative accuracy of the two methods.

The string galvanometer required very little attention to keep it in operation, but the results obtained were considerably more erratic and less accurate than the results obtained with the moving-coil galvanometer. Some of this erratic behavior seems to have been due to the poor condition of the bearings of the coil of earth-inductor 3. Considerable improvement in marine galvanometers is required before the sea dip-circle can be entirely supplanted by the marine earth-inductor for the determination of inclination at sea.

STRING GALVANOMETER.

The Department of Terrestrial Magnetism, in connection with its ocean work and special duties assigned to it in 1917, has had occasion to design, with the assistance of Dr. W. F. G. Swann, a special form of string galvanometer (see Pl. 3, Figs. 2 and 4), which was constructed in the instrument shop of the Department.

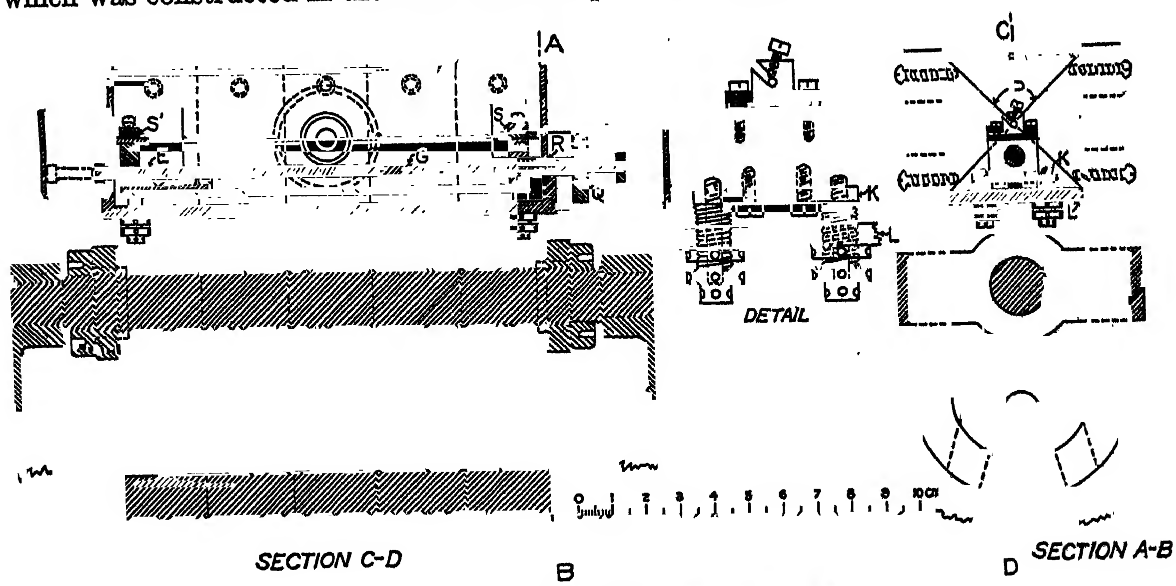


FIG. 2.—Details of String Galvanometer for Ship Use.

The galvanometer is of the string type originally developed by Professor Einthoven. It is of the permanent-magnet, air-damped pattern. The magnetic field is produced by a laminated magnet consisting of five permanent horseshoe-magnets. These magnets are of the permanent magnet-steel supplied by the Crucible Steel Company of America, and were made following the methods used by the Department of Terrestrial Magnetism for the manufacture of magnetometer magnets. To insure maximum flux-density in the gap, two pole pieces, P, of soft iron are attached, as shown in the section AB of Figure 2; the gap for the fiber is 2 mm. wide.

The string element consists of a fine quartz fiber coated with silver or platinum; it is soldered to two cylindrical copper lugs which may be clamped in the standards S and S' (see Fig. 2). These standards are mounted on the plate K, which in turn is mounted on the plate L by four adjusting sleeves and screws by which the plate K may be adjusted to exactly center the fiber in the gap. The tension of the fiber is regulated by means of the milled head Q, which may be clamped in the screw sleeve R. The pitch of the latter is slightly different from that of the screw E, which is mounted in the second standard S'. Because of the slight difference in the two pitches, it is possible to effect readily a fine adjustment of the fiber for tension. It should be noted that the standard S is fixed with reference to the plate K and that the standard S' is attached to a slide mounted between suitable clamps on the plate K. It is possible to alter quickly the distance between the two standards S and S' by unclamping the milled head Q and sliding the bar G with the standard S' one way or the other in the screw sleeve R. When the distance desired between the two standards is secured, the milled head Q is clamped and the final adjustment made. It is thus possible to use a fiber of any length between 93 mm. and 120 mm. In the present instrument the rod G is made of phosphor-bronze because invar-steel of proper size could not be obtained. For future instruments it is intended to use invar-steel in order to eliminate any possible effects due to the difference in temperature coefficients for the bronze rod and for the quartz fiber. Suitable cover plates and caps (see Pl. 3, Fig. 2) are provided to exclude dust and air currents.

The small deflection of the fiber produced at right angles to the magnetic field by the passage of a current through the galvanometer is observed by projecting the image of the fiber on a glass scale by means of a beam of light passing through the microscopes and suitably mounted prisms (see Fig. 2 of Plate 3, showing the microscopes but not the attachments for the prisms and scale). One of the microscopes serves as the optical condenser. The microscopes are mounted on adjustable carriers on either side of the central magnet-section, holes of suitable size being drilled through the section to permit the necessary adjustments of the objectives by the fine focusing arrangements. The diameter of these holes is 2 mm. greater than the diameter of the tube containing the objectives, to permit centering of the microscope on the fiber; the free spaces about the objective tubes are packed with cotton when the instrument is in use.

The galvanometer is mounted in a frame (see Pl. 3, Figs. 2 and 4) so arranged that it may be set up with the fiber either in a horizontal or a vertical position. The bearings of the axles supporting the magnets with their appurtenances are provided with two clamping screws, so that the instrument may be clamped in any position in its bearings.

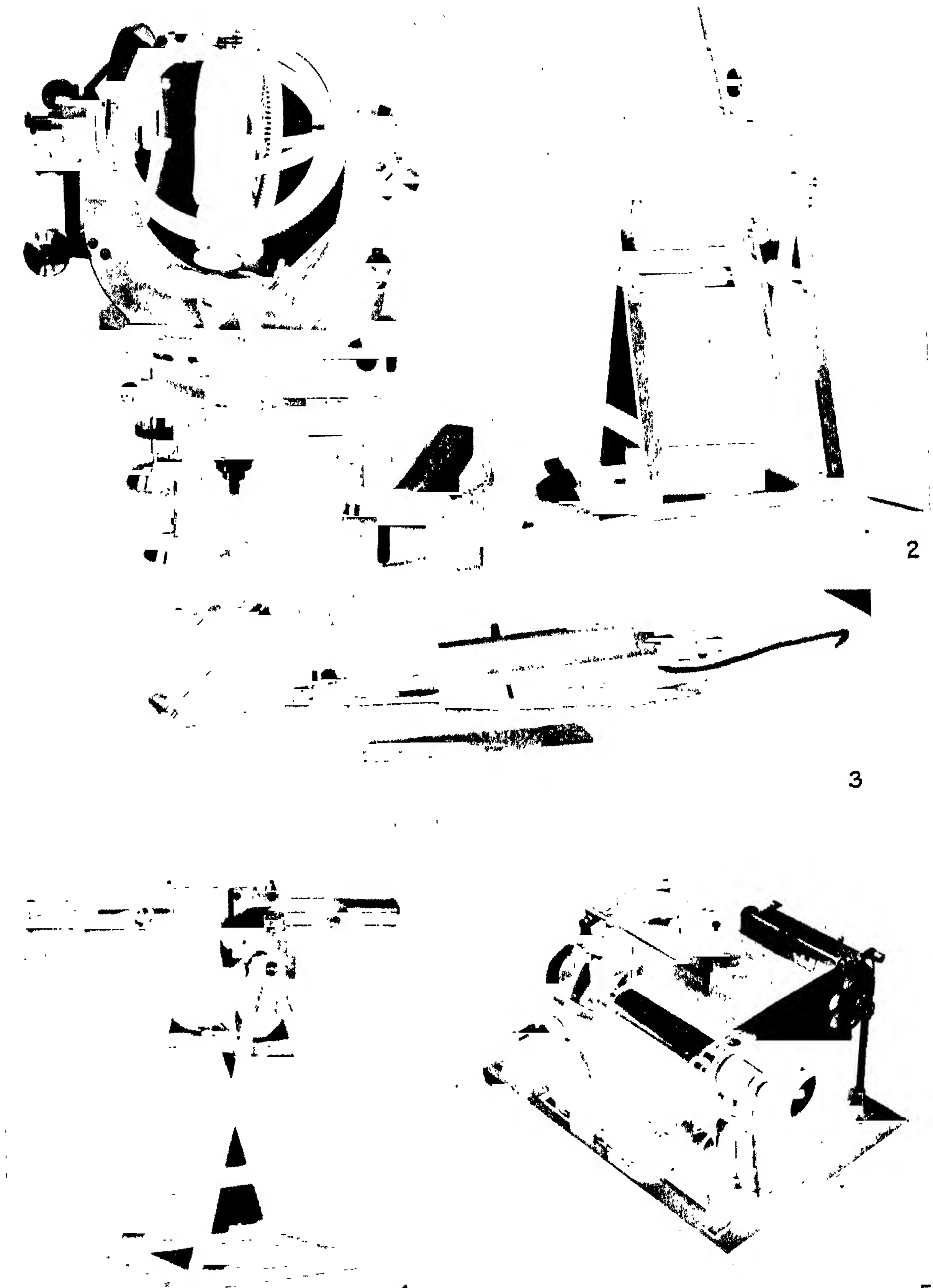
When used aboard ship it was found that vibrations, for example those from the engine, could be practically eliminated by suspending the galvanometer from the beams in the cabin with strong rubber bands.

The fibers are coated by the method described by Professor H. B. Williams, and the resistances range from 2,000 ohms upward. Fibers of diameter 0.001 to 0.002 mm. are, on the whole, the most convenient.

METHOD OF OBSERVATION.

As the alternating current, generated by the rotating slip-ring coil of the earth-inductor, passes through the string galvanometer, the fiber is deflected back and forth rapidly at right angles to the magnetic field, the rapidity of the vibrations causing the image of the moving fiber to form a continuous band. The width of this band is a measure of the amount by which the axis of the earth-inductor coil is out of the line of magnetic dip.

Referring to the specimen observation with this slip-ring coil earth-inductor and string-galvanometer combination on pages 27 and 28, if the width of the band is read



NEW INSTRUMENTS USED ON CRUISE VI.

1. C. I. W. marine earth-inductor 7. 2. String galvanometer showing fiber mounting. 3. Slip-ring coil for earth inductor and improved D'Arsonval balance for galvanometer. 4. String galvanometer assembled. 5. Sperry automatic roll-and-pitch recorder.

OCEAN MAGNETIC OBSERVATIONS: EARTH-INDUCTOR OBSERVATIONS (GALVANOMETER READINGS)

(Form 39a)

Station: At Sea.	Lat. 11° 47' N	Long. 104° 34' W
Date: Fri., June 17, 1921, P. M.	Vessel: Carnegie	Com'd'r: J. P. A.
Instrument: Earth Ind'r 1	Obs'r: H. R. G.	Rec'd'r: H. F. J.
Obs'r's wt. 5	Comp'r: H. F. J.	Review: R. R. M.

V. C. of inductor	East				West			
V. C. setting, a	1		2		3		4	
Crank turn	r	l	r	l	r	l	r	l
	d	d	d	d	d	d	d	d
Scale readings* 1	2 0	3 0	2 5	3 0	2 0	2 0	2 0	3.0
" " 2	1 5	2 5	3 0	4 0	3 5	1 0	3 0	1 5
" " 3	2 5	2 5	3 0	3 0	3 5	2 5	4 0	3 5
" " 4	3 0	4 0	1 0	3 0	4 0	5 0	1 0	3 5
" " 5	2 5	3.0	1 5	3 0	3 5	3 0	2 5	2 0
" " 6	3 5	1 5	2 5	3 0	1 5	1 0	3 0	3 0
" " 7	1 5	1 0	3 0	2 5	2 5	1 5	3 5	4 0
" " 8	2 5	2 5	5 0	3 0	3 5	2 5	3.0	3 0
" " 9	2 5	5 0	4 0	3 0	3 0	3 0	2 0	2 0
" " 10	3 0	4 0	3 0	2 5	3 5	2 0	1 0	2 5
Means	2 45	2 90	2 85	2 70	2 75	2 35	2 60	2 70
Means, r and l	d 2.68 = d_1		d 2.78 = d_2		d 2.55 = d_3		d 2.60 = d_4	
Sums ($d_1 + d_{2..}$)	d 5.38 = $d_1 + d_2$				d 5.15 = $d_3 + d_4$			

V. C.' of inductor	West				East			
V. C.' setting, a	5		6		7		8	
Crank turn	r	l	r	l	r	l	r	l
	d	d	d	d	d	d	d	d
Scale readings* 1	3 0	3 0	2 0	3 0	3 0	2 0	3 0	3 0
" " 2	3 5	3 0	1 0	2 5	1 0	2 5	3 5	2 0
" " 3	2 5	2 0	3 5	2 5	0 5	4 0	3 0	2 5
" " 4	3 5	1 0	4 0	2 5	2 5	3 0	2 0	3 0
" " 5	3 0	2 0	3 0	3 0	4 0	1 5	1 5	3 0
" " 6	2 5	4 0	2 0	4 0	3 0	2 0	3 5	3 5
" " 7	2 5	3 0	1 5	3 0	2 5	2 5	4 0	3 5
" " 8	3 0	1 5	3 0	1 5	3 0	2 5	3 0	3 5
" " 9	1 5	2 5	4 0	1 0	1 5	5 0	2 0	3 0
" " 10	1 5	4.0	2 0	2 5	4 0	2 5	3 0	2 0
Means	2 60	2 60	2 60	2 55	2 40	2 70	2 85	2 90
Means, r and l	d 2.60 = d_5		d 2.58 = d_6		d 2.55 = d_7		d 2.88 = d_8	
Sums ($d_5 + d_{6..}$)	d 5.20 = $d_5 + d_6$				d 5.45 = $d_7 + d_8$			

Remarks: * Reading width of band made by oscillating fiber or difference between extreme oscillations.

Ocean Magnetic Observations. Earth-Inductor Observations for Inclination

[illegible]

Circle East

Commutator Up | Commutator Down

[illegible]

Mean

Circle Reversed

[illegible]

Mean

Mean Inclination, Commutator Up | Mean Inclination, Commutator Down

Mean Inclination, Circle East | Mean Inclination, Circle Reversed

Resulting Mean Inclination

[illegible]

Remarks: Magnetic articles removed: Yes

[illegible]

as 2.55 divisions of the scale for the mean of right-hand and left-hand rotation of the crank for setting No. 3 of the vertical circle of the earth-inductor, 339°.48, and the width of the band is read as 2.60 divisions for the vertical-circle setting No. 4, 333°.48, then the line of inclination is found by multiplying the shift of 6° in the vertical-circle setting by the fraction $\frac{2.55}{5.15}$, which amounts to 2°.97, to be subtracted from vertical-circle setting No. 3.

Thus, if S_n is the nth vertical-circle setting, the reading of the vertical circle for the position of balance, or of no deflection, and, consequently, of the true line of magnetic dip, would be

$$S_n + \left(\frac{d_n}{d_n + d_{n+1}}\right)\Delta$$

where d_n is the mean width of the band formed by the oscillating fiber for right-hand and left-hand rotation of the crank for vertical-circle setting S_n, d_{n+1} the corresponding quantity for the $(n+1)$ setting of the vertical circle, and Δ is the algebraic difference between the two settings of the vertical circle, *i. e.*, $\Delta = S_{n+1} - S_n$.

A shift of 2° in the vertical-circle setting of the earth-inductor gave a deflection of the galvanometer fiber too small to be read with sufficient accuracy, so that it was finally decided, after experimenting with shifts of 2°, 4°, 6°, and 8°, to use a shift of 6°, or to set the vertical circle of the inductor as nearly as was possible 3 degrees each side of the true line of magnetic dip. It was first attempted to read the extreme deflections of the fiber, but owing to the motion of the vessel this was found to be impracticable. The width of the band formed by the moving fiber was not affected by the motion of the vessel, so that it was possible to estimate this width with considerable accuracy, even when the band moved up and down on the scale with the motion of the vessel. Except as noted above, the scheme of observation is the same as for the moving-coil galvanometer described on page 201, Volume III.

INSTRUMENTAL OUTFIT FOR THE CARNEGIE WORK

CRUISES IV AND V, MARCH 1915 TO JUNE 1916

Magnetic Instruments

I. *For magnetic declination at sea.*—(1) Marine collimating-compass 1, same as for Cruise III, designed and constructed by the Department of Terrestrial Magnetism, provided with brass binnacle-stand and deflector attachment for use on board ship and tripod with rotating arm and appurtenances for mounting theodolite for use on shore; (2) sea deflector 3, same as for Cruise III, designed and constructed by the Department of Terrestrial Magnetism, was on board for possible emergency use to October 1916; (3) sea deflector 4, same as for Cruise III, designed and constructed by the Department of Terrestrial Magnetism, provided with brass binnacle-stand by E. S. Ritchie and Sons, for use on board ship, with tripod for use on shore, and with a special quick-sighting device for navigational purposes, was used to October 1916, after which it was retained on board for possible emergency use; (4) sea deflector 5, designed and constructed by the Department of Terrestrial Magnetism, was on board from April to October 1916 for reserve and experimental use, and from October 1916 it was used in place of deflector 4. The designations adopted, respectively, for these four compasses with appurtenances are C1, D3, D4, and D5. (5) Ritchie liquid compass 29670, same as for Cruise III, provided with a brass binnacle-stand, by E. S. Ritchie and Sons, was mounted in the chart-room and used as the standard compass; (6) Ritchie liquid compass 29971, same as for Cruise III, provided with a brass binnacle-stand, by E. S. Ritchie and Sons, was mounted on the quarter-deck and was used as a steering compass for the vessel; (7) Ritchie liquid compass 29499, and (8) Ritchie liquid compass 29497, the latter with its card ungraduated except for the four cardinal points, with azimuth circles 418-III and 481-III, all by E. S. Ritchie and Sons, were carried for reserve and experimental use.

II. *For magnetic inclination and total intensity at sea.*—(1) Sea dip-circle 189, same as for Cruise III, used from April 1915, provided with dip needles 1, 2, 5, and 6, and intensity-needle pairs 3 and 4, and 11 and 12, provided with reversible gimbal-stand for use on board ship and tripod for use on shore; (2) sea dip-circle 204, same as for Cruise III, used during March 1915, after which it was a reserve instrument, provided with dip needles 2, 9, 10, and 11, and intensity-needle pairs 3 and 4, and 7 and 8;[1] (3) marine earth inductor 3,[2] same as for Cruise III, with the addition, for use at shore stations, of galvanometer 28A and tripod, designed and constructed by the Department of Terrestrial Magnetism, supplemented by moving-coil galvanometers 19498 (tube 19499) and 20096 (tubes 20097 to July 1917, and 20098). The designations adopted, respectively, for the three instruments and their appurtenances are 189.1234, 204.7834, and EI3. For the dip circles the intensity-needle numbers are italicized; for cases where both deflection and loaded-dip observations were made, the designation for the intensity [illegible] is followed by a dagger(†), thus, 189.1234†.

III. *For horizontal intensity at sea.*—(1) Sea deflector 4, same as for Cruise III, except for minor repairs during January 1915, with magnets 4S, 2L, and 3, to October 1916, after which it was supplanted by deflector 5; (2) sea deflector 5, with [illegible] 5 and 2L, from October 1916; (3) sea deflector 3 was on board from June 1916 to October 1916 for possible emergency use, after which deflector 4 was the reserve instrument.

IV. *For [illegible] declination and horizontal [illegible] on land.*—(1) Theodolite magnetometer 5, same as for Cruise III; (2) magnetometer-inductor 23, same as for Cruise

[1] Intensity needles 7 and 8 and dip needle 9 were returned to the office in April 1915, the pivots of 8 and 9 having been broken during [illegible].

[2] Earth inductor 3 was [illegible] overhauled and repaired in the [illegible] shop of the [illegible] of Terrestrial [illegible] during October 1916 while the Carnegie was at San Francisco.

III, except for overhauling and repairs during January 1915. The designations adopted, respectively, for these two magnetometers are 5 and 25. (3) Universal magnetometer 21, designed and constructed by the Department of Terrestrial Magnetism, was used at one shore station in March 1915.

V. *For magnetic inclination on land.*—(1) Magnetometer-inductor 25, same as for Cruise III, except that galvanometer 20X was substituted for galvanometer 25 from October 1916; (2) land dip-circle 201, provided with dip needles 5 and 6 of 201, 5X, and 6X, and intensity-needle pair 3 and 4, with tripod 201, all by A. W. Dover, until May 1916; (3) land dip-circle 202, provided with dip needles 7X and 8X and intensity-needle pair 3 and 4 to be used as dip needles, all by A. W. Dover, from September 1916; (4) land dip-circle 241, provided with dip needles 1, 2, 5, and 6, and intensity-needle pair 7 and 8, all by A. W. Dover, from April 1917. The designations adopted, respectively, for these four instruments are E125, 201.56, 202.7X8X, and 241.12. (5) Marine earth-inductor 3 was also used for shore observations; (6) universal magnetometer 21, provided with needles 1 and 3 of 19 and 3 and 4 of 20, was used at one shore station in March 1915.

ATMOSPHERIC-ELECTRIC INSTRUMENTS.

VI. *Instruments for observations in atmospheric electricity.*—(1) Conductivity apparatus 3 (designation CA3), designed and constructed by the Department of Terrestrial Magnetism, provided with gimbal rings and mounting and direct-current motor; (2) ion counter 1(IC1), provided with gimbal rings and mounting, and appurtenances, all designed and constructed by the Department of Terrestrial Magnetism; (3) penetrating-radiation apparatus 1(PRA1), provided with gimbal rings and mounting, and appurtenances, all designed and constructed by the Department of Terrestrial Magnetism; (4) potential-gradient apparatus 2(PG2), complete with appurtenances and mounting, all designed and constructed by the Department of Terrestrial Magnetism; (5) radioactive-content apparatus 4(RCA4), provided with gimbal rings and mounting, water-dropping apparatus, direct-current motor, ionizing chamber, anemometer, and other appurtenances, designed and constructed for the most part by the Department of Terrestrial Magnetism. (6) Accessories: Gerdien condenser 4, until April 1915, and from April to October 1916; Gerdien condenser 5, from October 1916; single-fiber electrometers 12, 14, and 15, all constructed by the Department of Terrestrial Magnetism; Braun electroscope 1437, Wulf bifilar electrometers 3537, 3995 (repaired in the instrument shop of the Department during October 1916), and 4357, all by Günther and Tegetmeyer; Wiechert electrometer 2 by Spindler and Hoyer; high-resistance rheostats 1716 and 1751, April to October 1916; Biddle rheostats 67257 and 78310; batteries of cadmium cells and Eveready dry cells; voltmeters; volt-ammeter; potentiometer; gimbal-stand; nonmagnetic Gauss table; radium and ionium collectors; miscellaneous equipment, including nonmagnetic clamps, special insulators, small tools, etc.

SEXTANTS, CHRONOMETERS, WATCHES, AND DIP-OF-HORIZON MEASURERS.

VII. *Sextants.*—(1) Nos. 2575, 2611, 2617, 2943, 2944, by Ponthus and Therrode (the last two instruments are specially designed for use at night); (2) No. 3265 by C. Plath; (3) Nos. 10756, 10759, and 22876, all by Keuffel and Esser Company; (4) Nos. L909 and M911 (from May 1916), by Heath and Company, London; (5) unnumbered sextant by L. Weule; (6) gyroscopic collimator and octant 2679 by Ponthus and Therrode; (7) pocket sextant 301 by James J. Hicks; (8) extra small sextants 3380 and 3393 by Carey, Porter Ltd.; (9) prismatic circle 11717 by Carl Bamberg.

VIII. *Chronometers and watches.*—(1) Marine chronometers 254 and 264 by A. Kittel, 360 by Finer, 2761 by G. E. Wilkins, 52917, 53151, 53157, and 53862, all by E. Dent and Company, 1044 by Roskell, with ship and gimbal cases; (2) watches 70 and 71 by the

Hamilton Watch Company, 92 (sidereal) by the Waltham Watch Company, 106, 110, 116, 117, all by the Elgin National Watch Company. Watches 70, 71, 106, 110, 116, and 117 were returned to the office in October 1916, and the following watches were substituted for them: 53 and 137 by the Hamilton Watch Company, 101 and 105 by the Elgin National Watch Company, and 316 and 568 by the South Bend Watch Company.

IX. *Dip-of-horizon measurers.*—(1) Dip-of-horizon measurer 4048 by Carl Zeiss; (2) micrometer dip-of-horizon measurer 4031 by Carl Zeiss, loaned by the United States Coast and Geodetic Survey until July 1915, designated No. 1 of that survey; (3) dip-of-horizon measurer 5490 by Carl Zeiss, from July 1915.

METEOROLOGICAL INSTRUMENTS AND MISCELLANEOUS EQUIPMENT.

X. *Meteorological instruments.*—(1) Aneroid barometers 4 and 7 by Ponthus and Therrode; (2) unnumbered holosteric aneroid barometer by L. Weule; (3) barograph 5142 by Richard Frères; (4) marine mercury barometer 3948, English and metric scales and verniers, Weather Bureau No. 7272, provided with attached unnumbered Fahrenheit thermometer and Bureau of Standards No. 1244 centigrade thermometer by H. J. Green; (5) marine mercury barometer 4177, English and metric scales and verniers, Weather Bureau No. 7273, provided with attached unnumbered Fahrenheit thermometer and centigrade thermometer, Bureau of Standards No. 2072, by H. J. Green; (6) boiling-point apparatuses 8 and 9 by the Department of Terrestrial Magnetism; (7) Marvin sling psychrometer 204 by Schneider Brothers, and two sling psychrometers by H. J. Green, thermometers 29034, 29035, 29036, and 29037 from October 1916; (8) thermographs 40034, 40418, and 46032, by Richard Frères; (9) 6-inch thermometers, Bureau of Standards Nos. 2666, 4141 (with deflector 5 from April 1916), 4144 (from October 1916), 4149, 4151, 4160, 4161, 8186 (with magnetometer-inductor 25), 9515 (from April 1917), 9517, 9520, 9521, 9523 (from October 1916), 9526 (from October 1916), 9530, 9531, and 9532; (10) thermometers for hypsometric work at sea, Bureau of Standards Nos. 3553, 3554, 7828, 7831, 8116, 8117, 8118, 8119, 8728, 8730, 8731, 11071, and 11076; (11) maximum thermometer 8094 and minimum thermometer 8070, both Fahrenheit scale, by H. J. Green; (12) special reading telescope and mounting for boiling-point work at sea, designed and constructed by the Department of Terrestrial Magnetism. The following thermometers were broken during cruises IV and V: 9517, 9521, 9532, 7831, 8116, 8117, 8118, 8728, and 8730.

XI. *Miscellaneous equipment.*—(1) Artificial horizon 2, designed and constructed by the Department of Terrestrial Magnetism; (2) leather chronometer-carrying cases; (3) balances; (4) six Edison primary batteries with coil for reversing magnetization of sea dip-circle needles; (5) marine clocks; (6) two 3-inch liquid boat-compasses and brass binnacles; (7) dating and numbering machines; (8) drawing tools; (9) plate and film cameras; (10) leads for sounding; (11) marine glasses; (12) taffrail logs; (13) universal levels; (14) inclinometers; (15) instrument trunk-cases; (16) miscellaneous office equipment; (17) microscope 2 and accessories, by Spencer Lens Company (maker's No. 10477); (18) medical and surgical supplies and instruments; (19) developing tank for photographic work; (20) three-arm protractor 10031, by the Keuffel and Esser Company; (21) reading glasses; (22) Tanner nonmagnetic 100-fathom sounding machine 1, by D. Ballauf (maker's No. 245); (23) tapes; (24) nonmagnetic observing pyramid tents, regulation land type, for shore work; (25) special nonmagnetic wall tents 9 feet by 9 feet, for shore work; (26) tools; (27) typewriter; (28) small instrumental accessories; (29) water filters; (30) telescope 1 by Carey; (31) comptometer; (32) 40 Edison primary batteries for supplying current for atmospheric-electric work; (33) fog horn; (34) Lyle nonmagnetic life-line gun.

CRUISE VI, OCTOBER 1919 TO NOVEMBER 1921.

MAGNETIC INSTRUMENTS.

XII. *For magnetic declination at sea.*—(1) Marine collimating-compass 1, same as for cruises IV and V; (2) sea deflector 5, same as for cruises IV and V. The special sighting device or azimuth circle constructed for deflector 4 was adapted for use with deflector 5. The designations adopted, respectively, for the two compasses with appurtenances are C1 and D5; (3) Ritchie liquid compass 39670 used as standard, same as for cruises IV and V; (4) Ritchie liquid compass 29971 used as steering compass, with Ritchie azimuth device 481-III, same as for cruises IV and V; (5) Ritchie liquid compass 29499, and (6) Ritchie liquid compass 29497, same as for cruises IV and V; (7) sea deflector 4 was on board for possible emergency use.

XIII. *For magnetic inclination and total intensity at sea.*—(1) Sea dip-circle 189, same as for cruises IV and V, with dip needles 1, 2, 5, 6, 9, and 10, and intensity-needle pairs 3 and 4, 7 and 8, and 11 and 12. Dip needles 1 and 2 were used throughout Cruise VI and intensity-needle pair 3 and 4 were used to November 27, 1920, when they were replaced by intensity-needle pair 11 and 12, owing to broken pivot of needle 3; (2) sea dip-circle 169, with dip needles 5, 6, 9, and 10, and intensity-needle pairs 7 and 8, and 11 and 12, was on board as a reserve instrument; (3) marine earth inductor 3, same as for cruises IV and V, provided with special slip-ring coil and new string galvanometer 1 from February 1920, all designed and constructed by the Department of Terrestrial Magnetism; (4) marine earth-inductor 7, designed and constructed by the Department of Terrestrial Magnetism, supplemented by moving-coil galvanometers 19498 (tubes 19499 and 20698) and 20696 (tubes 20697 from February 1920 and tubes 62312 and 62313 from March 1921), with the addition, for use at shore stations, of galvanometer 28X and tripod until July 1921. The designations adopted, respectively, for these four instruments and their appurtenances are 189.12*34*, 169.56*78*, EI3, and EI7. For the dip circles the intensity-needle numbers are italicized; for cases where both deflection and loaded-dip observations were made, the designation for the intensity needles is followed by a dagger (†), thus, 189.12*34*†.

XIV. *For horizontal intensity at sea.*—(1) Sea deflector 5, same as for cruises IV and V, with magnets 5, 2L, and 3; (2) sea deflector 4 was on board as a reserve instrument.

XV. *For magnetic declination and horizontal intensity on land.*—(1) Theodolite magnetometer 5, same as for cruises IV and V, until July 1921; (2) magnetometer inductor 25, same as for cruises IV and V. The designations adopted, respectively, for these two magnetometers are 5 and 25.

XVI. *For magnetic inclination on land.*—(1) Magnetometer-inductor 25, same as for cruises IV and V, with galvanometer 25 and extra galvanometer 29X; (2) marine earth-inductor 7, with galvanometer 28X until July 1921, was also used for shore observations; (3) land dip-circle 202, same as for Cruise V, provided with dip needles 7X and 8X and intensity-needle pair 7 and 8, was on board as a reserve instrument.

ATMOSPHERIC-ELECTRIC INSTRUMENTS.

XVII. *Instruments for observations in atmospheric electricity.*—(1) Conductivity apparatus 3 (designation CA3), same as for cruises IV and V; (2) ion counter 1 (IC1), same as for cruises IV and V; (3) penetrating-radiation apparatus 1 (PRA1), same as for cruises IV and V; (4) potential-gradient apparatus 2 (PG2), same as for cruises IV and V; (5) radioactive-content apparatus 4 (RCA4), same as for cruises IV and V; (6) accessories: Gerdien condenser 5; single-fiber electrometers 12, 14, and 15, same as for cruises IV and V; Wulf bifilar electrometers 3537, 3995, and 4357 (to July 1921), same as for cruises IV and V; Braun electroscope 1437; high-resistance rheostats 78311, 68209, and 26158; Zamboni dry pile from February 1920; ionium collectors 3 and 4; Gambrell

megohms 1369 and 1078 (from October 1920); batteries of silver-chloride dry-cells; voltmeters; volt-ammeter; potentiometer; miscellaneous equipment, including non-magnetic clamps, special insulators, small tools, etc.

SEXTANTS, CHRONOMETERS, WATCHES, AND DIP-OF-HORIZON MEASURERS.

XVIII. *Sextants.*—Same as for cruises IV and V.

XIX. *Chronometers and watches.*—(1) Marine chronometers, same as for cruises IV and V, with the exception of Kittel 254, Finer 360, and Roskell 1044, and with the addition of pocket chronometers 50110 and 50097 (from April 1920) by Paul Ditisheim, and 226 by A. Kittel, to February 1920; (2) watches, 51 by the Hamilton Watch Company, 91 (sidereal) by the Waltham Watch Company, 104 and 111 by the Elgin National Watch Company, 568 by the South Bend Watch Company, and 811 and 813 by the Howard Watch Works.

XX. *Dip-of-horizon measurers.*—(1) Dip-of-horizon measurers 4048 and 5490, same as for cruises IV and V; (2) sextant 2611 was used to determine the atmospheric refraction by measuring altitudes of the Sun and of Venus when these objects were near the zenith.

METEOROLOGICAL INSTRUMENTS AND MISCELLANEOUS EQUIPMENT.

XXI. *Meteorological instruments.*—(1) Aneroid barometer 3 by Keuffel and Esser; (2) unnumbered holosteric aneroid barometer by L. Weule; (3) barograph 5142 by Richard Frères; (4) marine barometers, same as for cruises IV and V; (5) boiling-point apparatuses, same as for cruises IV and V; (6) 5 Marvin sling psychrometers by H. J. Green, aluminum frames, thermometers Nos. 34528 and 34529, 34448 and 34449, 29034 and 29035, 34544 and 34545, 29036 and 29037, 1 psychrometer No. G 108 by J. P. Friez, and 1 brass-frame psychrometer, thermometers Nos. 1248 (Bureau of Standards) and 8 (Schneider); (7) thermographs 39804 (C.I.W. 1), 40418 (C.I.W. 2) and 43032 (C.I.W. 4), by Richard Frères; (8) 6-inch thermometers, Bureau of Standards Nos. 2072, 2666 (with magnetometer 5), 4141 (with deflector 5), 8186 (with magnetometer-inductor 25), 9513 (with dip circle 202), 9514, 9530, 9518, 13370, 13377, 6724, 6731, 13365, and from October 1920, 4160, 9523, 9526, 9531, 13363, 13380; (9) thermometers for hypsometric work at sea, Bureau of Standards Nos. 7828, 8119, 8731, 11071, and 11076. The following thermometers were broken during Cruise VI: 11076, 34528, 29034, and 29036.

XXII. *Miscellaneous equipment.*—Same as for cruises IV and V with the addition of (1) Sperry auto roll-and-pitch recorder, mark II, model 6, serial No. 2, 7,000 R.P.M.; (2) statoscope 85574, by Richard Frères, from October 1921; (3) line-of-position computer by Charles L. Poor; (4) sounding tubes 38 and 39, loaned by the United States Coast and Geodetic Survey.

General property and supplies.—Besides the instrumental equipment listed on pages 33 and 34, the general property and supplies on board the *Carnegie*, 1919–1921, in addition to what were necessary for the maintenance of the ship, were the same as for cruises IV and V.

SPECIMENS OF OBSERVATIONS AND COMPUTATIONS.

The instruments and methods used during Cruise VI remained much the same as for cruises IV and V, and reference can be made to Volume III, Researches of the Department of Terrestrial Magnetism, pages 212–225, for specimens of observations and computations. Specimens of observations and computations illustrating the use of the new string galvanometer and earth-inductor 3, provided with special slip-ring coil, will be found on pages 27 and 28.

GEOGRAPHIC POSITIONS AT SEA.

Methods and instruments similar to those in use during cruises IV and V were used during Cruise VI, and reference can be made to Volume III, Researches of the Department of Terrestrial Magnetism, pages 225–231, for descriptions and explanation of methods. Increased accuracy of positions at sea has resulted from the added experience of the observers. Frequent use was made of the planet Venus for daylight observations in connection with observations on the Sun.

REDUCTION FORMULAE AND DETERMINATION OF CONSTANTS.

MAGNETIC STANDARDS ADOPTED.

The Department's extensive intercomparisons of magnetic instruments at Washington, in the field, and at magnetic observatories in all parts of the Earth have made it possible to refer its data to provisional "International Magnetic Standards." Such data obtained prior to 1914 were discussed in detail in Volume II, pages 211 to 278; the corresponding data obtained during 1915 to 1921, reported in Volume IV, pages 395 to 475, bear out the conclusions reached in Volume II. The "International Magnetic Standards," as stated, are provisional, particularly for intensity, pending the completion and intercomparison of absolute instruments[1] designed to determine magnetic intensity by electric methods.[2] Meanwhile, the numerous comparisons with magnetic-observatory standards indicate that these provisional standards approach sufficiently close to probable international ones that they may be considered as fulfilling all practical requirements of a general magnetic survey of the Earth.

Accordingly, these provisional "International Magnetic Standards," designated I.M.S., have been adopted for the results contained in this volume. The results already published in Volumes I, II, and III were reduced to the standards, designated C.I.W., adopted before the compilation of intercomparison data made possible the adoption of provisional "International Magnetic Standards"; they may be referred to I.M.S. by the following relations:

Declination, D .... I.M.S. = C.I.W. $-$ 0'.1
Inclination, I .... I.M.S. = C.I.W. $+$ 0'.5
Horizontal intensity, H .... I.M.S. = C.I.W. $-$ 0.00015H

The results published in Volume IV were reduced to I.M.S.

The instruments used as standards by the Department during 1915 to 1921 were the same as those used prior to 1914 for results given in Volumes I and II, viz: In declination, C.I.W. magnetometer 3 with correction on I.M.S. of $-0'.1$ to observed values; in horizontal intensity, C.I.W. magnetometer 3 with zero correction on I.M.S. to observed values; in inclination, earth inductor 48, made by Schulze, with zero correction on I.M.S. to observed values.

CONSTANTS AND CORRECTIONS FOR SEA INSTRUMENTS.

The instrumental constants and corrections on standards (above) of the sea instruments used in the *Carnegie* work were determined at Washington and at the various ports visited, by comparisons with standardized land-instruments. The method adopted in the comparisons was generally that of simultaneous observations. In order to refer

[1] The Schuster-Smith magnetometer, constructed at the National Physical Laboratory, and the sine galvanometer, designed by Dr. S. J. Barnett and constructed by the Department of Terrestrial Magnetism, were completed early in 1921. It is greatly hoped that the expectations as regards high absolute precision of intensity determinations with these instruments may be fully realized and that early intercomparisons may be possible between them and standard magnetometers of different countries, in order to assist in determining upon international magnetic standards.

[2] See L. A. Bauer, *Terr. Mag.*, vol. 19, pp. 1–18, 1914; N. E. Dorsey, *Terr. Mag.*, vol. 18, pp. 1–38, 1913; W. A. Jenkins. *Phil. Mag.*, vol. 26, pp. 752–774, 1913; E. Mauz, *Physic. Zs.*, vol. 22, pp. 11–15, 1921; A. Schuster, *Terr. Mag.*, vol. 19, pp. 19–22, 1914; A. Tanakadate, *Proc. R. S. Edinburg*, vol. 12, 1883 to 1884 and *J. Coll. Sci.*, Tokio, vol. 2, pp. 160–262, 1888; N. Watanabe, *Proc. Phys.-Math. Soc. Japan*, ser 3, vol. 2, pp. 210–223, 1920; W. Watson, *Phil. Trans. R. A.*, ser. A, vol. 198, pp. 431–462, 1902.

values of the magnetic elements at one observing station to any of the others, station differences were carefully determined at each port from observations with the land instruments, following the methods described in Volume I (pp. 19, 20).

DECLINATION OBSERVATIONS.

Marine collimating-compass 1 (C1).—Marine collimating-compass 1 was used on the *Carnegie* throughout cruises IV, V, and VI. The instrument was cleaned in January 1915, but it has not been overhauled or adjusted since May 1914.

The adopted constants for cruises IV, V, and VI, resulting from least-square adjustment of all data obtained during the period from February 1915 to December 1921, are summarized from Tables 1 and 2 and are given in Table 3.

TABLE 3.—*Constants of Marine Collimating-Compass C1.*

For Cruise	Scale	Magnetic azimuth [1] Designation	Magnetic azimuth [1] Value	Scale elevation [2] Designation	Scale elevation [2] Value [3]	Scale value
IV	South......	A_{cs}	359°.79	m_s	+0°.01+1°.26Z	0°.97
	West.......	A_{cw}	89.69	m_w	+0.12	1.00
	North......	A_{cn}	179.87	m_n	+0.17−1.26Z	1.00
	East.......	A_{ce}	269.95	m_e	−0.12	1.02
V	South......	A_{cs}	359.79	m_s	+0.01+1.26Z	0.97
	West.......	A_{cw}	89.69	m_w	+0.07	1.00
	North......	A_{cn}	179.87	m_n	+0.17−1.26Z	1.00
	East.......	A_{ce}	269.95	m_e	−0.07	1.02
VI	South......	A_{cs}	359.79	m_s	+0.01+1.26Z	0.97
	West.......	A_{cw}	89.69	m_w	[4] +0.07−0°.10 (t−1919.62)	1.00
	North......	A_{cn}	179.87	m_n	+0.17−1.26Z	1.00
	East.......	A_{ce}	269.95	m_e	[4] −0.07+0.10 (t−1919.62)	1.02

[1] The magnetic azimuths are on the basis of I.M.S. and are reckoned continuously in a clockwise direction from the magnetic south as 0° through 360°.
[2] Elevations above the horizon are reckoned as positive and below the horizon as negative.
[3] The vertical intensity, Z, is expressed in C. G. S. units, and is reckoned as positive for the northern magnetic hemisphere and negative for the southern magnetic hemisphere.
[4] See Table 2 for these values corresponding to various values of the time, t.

Sea deflector 4 (D4).—Sea deflector 4 was used on Cruise IV up to San Francisco, September 1916. The instrument developed a slight leak in the inner lining of the bowl and the resulting air bubble was removed at Honolulu on June 9, 1915 and again at Christchurch on November 23, 1915. The adjustments were not altered by these changes. Periodic corrections to observed card-readings are so small as to be considered negligible and have not been applied. The "shadow" method was not used on Cruise IV and hence no corrections are given for this method. The corrections to observed card-readings by the "bright-line method" showed no appreciable variation with change in the Sun's altitude. Hence, for Cruise IV, the finally adopted correction A_{bc}, to observed card-readings is +0°.05 for all altitudes of the Sun.

Sea deflector 5 (D5).—Sea deflector 5 was used on Cruise IV beginning at San Francisco and throughout cruises V and VI. Periodic corrections to observed card-readings are so small as to be considered negligible and have not been applied. The "shadow method" has never been used at sea with this instrument. The correction A_{bc}, to observed card readings by the "bright-line method" showed no apparent variation with change in the Sun's altitude for cruises IV and V.

After the instrument was rebuilt in March-April 1919, the correction, A_{bc}, to observed card-readings, showed some variation with change in the Sun's altitude for Cruise VI and the values finally adopted for cruises IV, V, and VI are given in Table 4.

TABLE 4.—*Corrections to Observed Card-Readings of Compass D5.*

For Cruise	Period	$A_{b\epsilon}$ for Sun's altitude 0°	5°	10°	15°	20°	25°	30°	35°
IV	Sept. 1916 to Mar. 1917........	+0.03	+0.03	+0.03	+0.03	+0.03	+0.03	+0.03	+0.03
V	Dec. 1917 to June 1918.........	+0.03	+0.03	+0.03	+0.03	+0.03	+0.03	+0.03	+0.03
VI	Oct. 1919 to Nov. 1921.........	+0.06	+0.07	+0.09	+0.11	+0.13	+0.15	+0.17	+0.19

HORIZONTAL-INTENSITY OBSERVATIONS WITH SEA DEFLECTOR.

The horizontal intensity is computed from sea-deflector observations by the formula

$$H=\frac{mC}{\sin u}$$

in which m is the magnetic moment of the deflecting magnet, C is a constant involving the deflection distance r, the distribution coefficients P and Q, the induction factor $\mu=mh$ (h being the induction coefficient for the deflecting magnet), and u the observed angular deflection produced by the deflecting magnet when its axis is perpendicular to that of the compass. The sea deflector is a relative instrument, and values of the so-called constant, $mC=H \sin u$, must be determined from comparison horizontal-intensity observations, made at shore stations with standardized absolute instruments.

The constant, mC, is subject to changes arising from (1) decrease in m with time, (2) effects of temperature variations on m and r, and (3) effects of change in vertical intensity, Z. In the *Carnegie* work all available data for log mC were subjected to least-square adjustment based on the general form[1]

$$\log mC=\log mC_{20} \text{ at } \tau_0+x\Delta\tau+y(z-Z)^2+q(20°-t)$$

in which τ is the date of observation expressed in years, τ_0 is the selected reference date, $\Delta\tau$ is $(\tau-\tau_0)$, q is the factor representing the combined effect of a change in temperature of 1° centigrade on m and C (on the latter because of the change in r), and t is the temperature of observation; the standard temperature of reference is 20° centigrade. Instead of deriving all the unknowns simultaneously it is found better to make a separate determination of the temperature factor q, selecting the observations best suited for that purpose. The final results were arrived at by a process of successive approximations, in the last steps of which q was treated as a constant. The values of mC as observed at shore stations during cruises IV, V, and VI for deflectors 4 and 5, and the computed values of that constant are given in Tables 6, 8, and 10. The formulae for log mC derived by least-square adjustments of all available shore data are given in Tables 5, 7, and 9.

Sea deflector 4.—The adopted constants for Cruise IV from March 1915 to September 1916, on the basis of I.M.S. (see p. 35), resulting from least-square adjustments of all the available data from shore determinations of log mC during Cruise IV, are given in Table 5.

The values of log mC for Cruise IV as observed at shore stations and the values as computed from the adopted formulae as given in Table 5, together with the differences between observed and computed values, are given in Table 6.

Sea deflector 5, cruises IV and V.—The adopted constants, on the basis of I.M.S. (see p. 35), resulting from least-square adjustments of all the available data from shore determinations of log mC during cruises IV and V, are given in Table 7.

[1] For further discussion of this equation and the theory of the deflector, see pp. 238 and 239, Vol. III, *Res. Dep. Terr. Mag.*

TABLE 5.—*Intensity Constants of Sea Deflector 4 for Cruise IV.*

Period	Deflecting magnet	Deflection distance[1]	Logarithms of the intensity constant[2]
Mar. 1915 to Sept. 1916	45	1	$mC=9.05708+0.00130\Delta\tau-0.00105(-0.265-Z)^2+0.00026(20°-t)$
	45	3	$mC=8.93069+0.00129\Delta\tau-0.00024(-0.303-Z)^2+0.00026(20°-t)$
	45	4	$mC=8.87705+0.00062\Delta\tau+0.00088(+0.361-Z)^2+0.00026(20°-t)$
	2L	1	$mC=8.98079-0.00033\Delta\tau+0.00387(-0.144-Z)^2+0.00014(20°-t)$
	2L	3	$mC=8.85412-0.00077\Delta\tau+0.00596(-0.096-Z)^2+0.00014(20°-t)$
	2L	4	$mC=8.80035-0.00086\Delta\tau+0.00706(-0.138-Z)^2+0.00014(20°-t)$
Mar. 1916[3]	3	2	$mC=8.64379+0.00025(20°-t)-0.00172\Delta\tau$
	3	3	$mC=8.57984+0.00025(20°-t)-0.00261\Delta\tau$
	3	4	$mC=8.52837+0.00025(20°-t)-0.00110\Delta\tau$

[1] Distance 2 for magnets 45 and 2L and distance 1 for magnet 3 were not used at sea.
[2] $\Delta\tau$ for magnets 45 and 2L $=(\tau-1915.86)$; for magnet 3 $\Delta\tau=(\tau-1916.28)$.
[3] The values for magnet 3 depend on determinations at only two land stations, and at these stations the value of Z is the same. Hence no Z correction can be determined. Magnet 3 was used only during March 18–22, 1916.

TABLE 6.—*Intensity Constants of Sea Deflector (4) Determined at Shore Stations During Cruise IV.*

Station	Date	Magnetic elements				Logarithms of intensity constants mC,[1] observed values at temperature t					
						Magnet 45			Magnet 2L		
						Distance			Distance		
		H	I	Z	t	1	3	t	1	3
		c. g. s.	°	c. g. s.	C					
Washington, N_m	1915.13	0.191	+71.0	+0.557	5°0	9.05530	8.92925	5°3	8.98342	8.85748
Colon, Sweetwater, *A*	1915.24	.322	+36.0	+ .234	29.6	9.05569	8.92948	29.2	8.98179	8.85539
Honolulu Observatory, *A*	1915.42	.290	+39.5	+ .239	30.5	9.05621	8.93018	30.6	8.98083	8.85504
Dutch Harbor, *B*	1915.57	.209	+66.3	+ .476	15.0	9.05658	8.93046	15.4	8.98205	8.85587
Christchurch[2]	1915.89	.224	−68.1	− .557	17.8	9.05734	8.93128	17.8	8.98144	8.85536
Do	1916.27	.224	−68.1	− .557	20.2	9.05724	8.93099	20.2	8.98124	8.85507
Guam, Sumay, *A*	1916.57	.349	+14.0	+ .087	30.4	9.05809	8.93162	30.4	8.98125	8.85382
Goat Island, *B*	1916.79	.250	+62.0	+ .470	13.7	9.05749	8.93159	14.1	8.98173	8.85539

Station	Date	Logarithms of intensity constant mC,[1] computed values[3] at temperature t				Logarithm differences (observed minus computed)			
		Magnet 45		Magnet 2L		Magnet 45		Magnet 2L	
		Dist. 1	Dist. 3	Dist. 1	Dist. 3	Dist. 1	Dist. 3	Dist. 1	Dist. 3
Washington, N_m	1915.13	9.05542	8.92957	8.98293	8.85722	−0.00012	−0.00032	+0.00049	+0.00026
Colon, Sweetwater, *A*	1915.24	9.05601	8.92982	8.98154	8.85525	− .00032	− .00034	+ .00025	+ .00014
Honolulu Observatory, *A*	1915.42	9.05624	8.93005	8.98151	8.85513	− .00003	+ .00013	− .00068	− .00009
Dutch Harbor, *B*	1915.57	9.05612	8.93017	8.98238	8.85619	+ .00046	+ .00029	− .00033	− .00032
Christchurch[2]	1915.89	9.05703	8.93071	8.98144	8.85537	+ .00031	+ .00057	.00000	− .00001
Do	1916.27	9.05752	8.93120	8.98131	8.85517	− .00028	− .00021	− .00007	− .00010
Guam, Sumay, *A*	1916.57	9.05787	8.93157	8.98077	8.85377	+ .00022	+ .00005	+ .00048	+ .00005
Goat Island, *B*	1916.79	9.05772	8.93175	8.98194	8.85531	− .00023	− .00016	− .00021	+ .00008

[1] All values are based on I.M.S.
[2] The observations were made at stations *Brass Pipe* and *Jarrah Peg* in the Observatory grounds.
[3] For the formulae adopted from least-square adjustments, see Table 5.

TABLE 7.—*Intensity Constants of Sea Deflector 5 for Cruises IV and V.*

Period	Deflecting magnet	Deflection distance[1]	Logarithms of the intensity constant[2]
Sept. 1916 to June 1918	5	1	$mC=9.17337-0.00036\Delta\tau+0.00402(-0.002-Z)^2+0.00015(20°-t)$
	5	3	$mC=9.04756-0.00038\Delta\tau+0.00347(-0.035-Z)^2+0.00015(20°-t)$
	2L	1	$mC=8.97215+0.00019\Delta\tau+0.00442(+0.025-Z)^2+0.00014(20°-t)$
	2L	3	$mC=8.84551+0.00007\Delta\tau+0.00504(+0.044-Z)^2+0.00014(20°-t)$

[1] Distances 2 and 4 were not used at sea. [2] $\Delta\tau=(\tau-1917.32)$ for magnet 5; $\Delta\tau=(\tau-1917.46)$ for magnet 2L.

The values of log mC for cruises IV and V as observed at shore stations and the values as computed from the adopted formulae as given in Table 7, together with the differences between observed and computed values, are given in Table 8.

TABLE 8.—*Intensity Constants of Sea Deflector 5, Determined at Shore Stations During Cruises IV and V.*

Station	Date	Magnetic elements *H*	*I*	*Z*	Logarithms of intensity constants mC,[1] observed values at temperature *t*: Magnet 5 *t*	Magnet 5 Distance 1	Magnet 5 Distance 3	Magnet 2L *t*	Magnet 2L Distance 1	Magnet 2L Distance 3
		c. g. s.	°	*c. g. s.*	*C*			*C*		
Washington, N_m	1916.18	0.189	+71.0	+0.549	8°8	9.17599	9.04971	9°0	....	....
Christchurch, *Jarrah Peg*	1916.32	.223	−68.1	− .555	15.9	9.17484	9.04887	16.0	8.97340	8.84725
Guam, Sumay, *A*	1916.58	.350	+14.0	+ .087	30.2	9.17356	9.04756	30.3	8.97144	8.84477
Goat Island, *B*	1916.77	.250	+62.0	+ .470	15.7	9.17408	9.04839	15.9	8.97354	8.84704
Pilar Observatory, *E*	1917.21	.255	−25.7	− .123	27.9	9.17348	9.04732	28.0	8.97203	8.84569
Do.	1917.83	.254	−25.7	− .122	30.3	9.17354	9.04759	30.7	8.97254	8.84555
Lima, *B*	1918.20	.302	− 0.8	− .004	25.0	9.17329	9.04764	25.0	8.97270	8.84595
Cristobal, *A* and *B*	1918.35	.321	+36.6	+ .238	29.5	9.17289	9.04756	29.5	8.97244	8.84595
Washington, N_m	1918.45	.188	+71.1	+ .549	20.8	9.17363	9.04797	20.9	8.97313	8.84634

Station	Date	Logarithms of intensity constant mC,[1] computed values[2] at temperature *t*: Magnet 5 Dist. 1	Magnet 5 Dist. 3	Magnet 2L Dist. 1	Magnet 2L Dist. 3	Logarithm differences (observed minus computed): Magnet 5 Dist. 1	Magnet 5 Dist. 3	Magnet 2L Dist. 1	Magnet 2L Dist. 3
Washington, N_m	1916.18	9.17500	9.04917	....	....	+0.00099	+0.00054	....	....
Christchurch, *Jarrah Peg*	1916.32	9.17496	9.04888	8.97342	8.84724	− .00012	− .00001	−0.00002	+0.00001
Guam, Sumay, *A*	1916.58	9.17367	9.04789	8.97200	8.84546	− .00011	− .00033	− .00056	− .00069
Goat Island, *B*	1916.77	9.17446	9.04865	8.97290	8.84637	− .00038	− .00026	+ .00064	+ .00067
Pilar Observatory, *E*	1917.21	9.17347	9.04763	8.97220	8.84563	+ .00001	− .00031	− .00017	+ .00006
Do.	1917.83	9.17325	9.04740	8.97232	8.84568	+ .00029	+ .00019	+ .00022	− .00013
Lima, *B*	1918.20	9.17305	9.04723	8.97229	8.84557	+ .00024	+ .00041	+ .00041	+ .00038
Cristobal, *A* and *B*	1918.35	9.17323	9.04743	8.97252	8.84576	− .00034	+ .00013	− .00008	+ .00019
Washington, N_m	1918.45	9.17418	9.04831	8.97356	8.84687	− .00055	− .00034	− .00043	− .00054

[1] All values are based on I.M.S. [2] For the formulae adopted from least-square adjustments see Table 7.

Sea deflector 5, Cruise VI.—The adopted constants, on the basis of I.M.S. (see p. 35), resulting from least-square adjustments of all the available data from shore determinations of log mC during Cruise VI, are given in Table 9.

TABLE 9.—*Intensity Constants of Sea Deflector 5 for Cruise VI.*

Period	Deflecting magnet	Deflection distance[1]	Logarithms of the intensity constant[2]
Oct. 1919	5	1	$mC = 9.17219 - 0.00044\Delta\tau + 0.00024(+0.157 - Z)^2 + 0.00015(20^\circ - t)$
to	5	3	$mC = 9.04700 - 0.00017\Delta\tau - 0.00200(-0.014 - Z)^2 + 0.00015(20^\circ - t)$
Nov. 1921			
Oct. 1919	2L	1	$mC = 8.97145 - 0.00003\Delta\tau + 0.00281(-0.063 - Z)^2 + 0.00014(20^\circ - t)$
to	2L	3	$mC = 8.84581 - 0.00068\Delta\tau - 0.00036(+0.010 - Z)^2 + 0.00014(20^\circ - t)$
July 1921			
July 1921	[3] 2L	1	$mC = 8.96495 - 0.00003\Delta\tau + 0.00281(-0.063 - Z)^2 + 0.00014(20^\circ - t)$
to	2L	3	$mC = 8.84001 - 0.00068\Delta\tau - 0.00036(+0.010 - Z)^2 + 0.00014(20^\circ - t)$
Nov. 1921			

[1] Distances 2 and 4 were not used at sea.
[2] $\Delta\tau = (\tau - 1920.74)$ for magnet 5; $\Delta\tau = (\tau - 1920.60)$ for magnet 2L.
[3] Some change, of unknown cause, took place in magnet 2L just after the comparison observations at Apia in July 1921; that the change occurred at Apia is borne out by comparisons of the sea values of H before and after this station, obtained separately from observations with the two magnets 5 and 2L. These comparisons and the comparison observations at Washington in November 1921 show that log mC should be diminished by 0.0065 for distance 1 and 0.0058 for distance 3.

The values of log mC for Cruise VI, as observed at shore stations and the values as computed from the adopted formulae as given in Table 9, together with the differences between observed and computed values, are given in Table 10.

TABLE 10.—*Intensity Constants of Sea Deflector 5, Determined at Shore Stations During Cruise VI.*

Station	Date	Magnetic elements			Logarithms of intensity constant mC,[1] observed values at temperature t					
					Magnet 5			Magnet 2L		
						Distance			Distance	
		H	I	Z	t	1	3	t	1	3
		c. g. s.	°	*c. g. s.*	C			C		
Washington, S_m and O.	1919.61	0.187	+71.2	+0.549	25°.5	9.17279	9.04646	25°.5	8.97235	8.84669
Buenos Aires, Florida, *A*	1920.10	.246	−27.8	− .130	29.3	9.17296	9.04727	29.4	8.97199	8.84616
Cape Town, Valkenberg, *C*	1920.34	.165	−61.5	− .304	20.4	9.17202	9.04678	18.4	8.97168	8.84588
Colombo, *A*	1920.52	.384	− 4.2	− .028	28.7	9.17179	9.04675	28.8	8.97103	8.84583
Fremantle, Cottesloe, *A*	1920.71	.239	−65.4	− .522	20.5	9.17218	9.04658	20.8	8.97151	8.84541
Christchurch, *Brass Pipe*	1920.83	.223	−68.2	− .558	17.4	9.17249	9.04636	17.0	8.97256	8.84541
San Francisco, Fort Scott, *B*	1921.18	.247	+62.3	+ .471	12.1	9.17211	9.04700	12.2	8.97248	8.84544
Apia Observatory, *B*	1921.51	.353	−30.0	− .204	29.2	9.17229	9.04686	29.5	8.97134	8.84520
Washington, N_m	1921.88	.186	+71.2	+ .546	18.5	9.17148	9.04584	18.9	[2] 8.96602	[2] 8.83902

[1] All values are based on I. M. S.
[2] These values were not used in the least-square reduction. Some change took place in magnet 2L just after the comparison observations at Apia. See foot-note 3, Table 9.

TABLE 10.—*Intensity Constants of Sea Deflector 5, Determined at Shore Stations During Cruise VI*—Continued.

Station	Date	Logarithms of intensity constant mC,[1] computed values[2] at temperature t				Logarithm differences (observed minus computed)			
		Magnet 5		Magnet 2L		Magnet 5		Magnet 2L	
		Dist. 1	Dist. 3	Dist. 1	Dist. 3	Dist. 1	Dist. 3	Dist. 1	Dist. 3
Washington, S_m and O..	1919.61	9.17273	9.04656	8.97253	8.84638	+0.00006	−0.00010	−0.00018	+0.00031
Buenos Aires, Florida, A.	1920.10	9.17249	9.04708	8.97148	8.84614	+ .00047	+ .00019	+ .00051	+ .00002
Cape Town, Valkenberg, C............	1920.34	9.17242	9.04690	8.97162	8.84595	− .00040	− .00012	+ .00006	− .00007
Colombo, A...........	1920.52	9.17230	9.04704	8.97145	8.84586	− .00051	− .00029	− .00042	− .00003
Fremantle, Cottesloe, A.	1920.71	9.17231	9.04649	8.97204	8.84564	− .00013	+ .00009	− .00053	− .00023
Christchurch, *Brass Pipe*	1920.83	9.17227	9.04639	8.97213	8.84553	+ .00022	− .00003	+ .00043	− .00012
San Francisco, Fort Scott, B............	1921.18	9.17202	9.04646	8.97223	8.84534	+ .00009	+ .00054	+ .00025	+ .00010
Apia Observatory, B...	1921.51	9.17188	9.04680	8.97148	8.84517	+ .00041	+ .00006	− .00014	+ .00003
Washington, N_m.......	1921.88	9.17173	9.04618	....	....	− .00025	− .00034	....	....

[1]All values are based on I.M.S. [2]For the formulae adopted from least-square adjustments see Table 9.

INCLINATION CORRECTIONS.

Sea dip-circle 189.—The adopted inclination corrections for sea dip-circle 189, resulting from least-square adjustments of all available data for each needle from shore observations during cruises IV and V, are given in Table 11, and during Cruise VI are given in Table 12. All corrections are on the basis of I.M.S. (see p. 35). For the regular dip needles, the inclination corrections apply to complete determinations by both polarities, and for the deflected needle, to the mean of determinations made in both "direct" and "reversed" positions. *All inclination values are referred to north-seeking end of needle, inclination of north-seeking end of needle below horizon being reckoned positive. All values of total intensity and horizontal intensity are reckoned positive; values of vertical intensity are given the same sign as the corresponding inclinations.* ΔI and ΔF in the formulae are always expressed in degrees and in C.G.S. units, respectively.

The following general formula (see Vol. I, p. 45, and Vol. III, pp. 242 to 252) was used in the least-square adjustments:

$$F\Delta I = x + y \sin I + z \cos I$$

TABLE 11.—*Inclination Corrections for Sea Dip-Circle 189, Cruises IV and V.*

Number of: Suspended needle	Deflecting needle	Deflection distance	Formulae for ΔI
1	....	....	$F\Delta I = +0.^\circ015 - 0.^\circ049 \sin I - 0.^\circ014 \cos I$
2	....	....	$F\Delta I = +0.013 - 0.027 \sin I - 0.016 \cos I$
$3D$ and R	4	Short	$F\Delta I = +0.039 - 0.024 \sin I - 0.120 \cos I$
$3D$ and R	4	Long	$F\Delta I = +0.030 - 0.046 \sin I - 0.114 \cos I$

The inclination corrections as observed at shore stations, and as computed from the adopted formulae in Tables 11 and 12, are given in Table 13 for cruises IV and V and in Table 14 for Cruise VI.

TABLE 12.—*Inclination Corrections for Sea Dip-Circle 189, Cruise VI.*[1]

Number of: Suspended needle	Number of: Deflecting needle	Deflection distance	Formulae for ΔI
1	....	....	$F\Delta I = +0.^\circ 058 - 0.^\circ 117 \sin I - 0.^\circ 135 \cos I$
2	....	....	$F\Delta I = +0.020 - 0.072 \sin I - 0.041 \cos I$
3*D* and *R*	4	Short	$F\Delta I = +0.082 - 0.079 \sin I - 0.197 \cos I$
3*D* and *R*	4	Long	$F\Delta I = -0.044 - 0.012 \sin I - 0.026 \cos I$
11*D* and *R*	12	Short	$F\Delta I = -0.082 + 0.021 \sin I + 0.009 \cos I$
11D and *R*	12	Long	$F\Delta I = +0.151 - 0.093 \sin I - 0.337 \cos I$

[1] Pivot of needle 3 was broken on November 26, 1920, and needles 11 and 12 were used in place of needles 3 and 4 for the remainder of Cruise VI.

TABLE 13.—*Inclination Corrections for Sea Dip-Circle 189, Determined at Shore Stations during Cruises IV and V.*

Station	Date	Magnetic elements: *I*	Magnetic elements: *F*	Observed ΔI[1]: Regular dip needles 1	Observed ΔI[1]: Regular dip needles 2	Observed ΔI[1]: Needle 3, *D* and *R*, deflected by needle 4, Distance Short	Observed ΔI[1]: Needle 3, *D* and *R*, deflected by needle 4, Distance Long	Computed ΔI[2]: Regular dip needles 1	Computed ΔI[2]: Regular dip needles 2	Computed ΔI[2]: Needle 3, *D* and *R*, deflected by needle 4, Distance Short	Computed ΔI[2]: Needle 3, *D* and *R*, deflected by needle 4, Distance Long
			c.g.s.								
Washington, N_m........	1915.12	+71°.0	0.585	−0°.06	−0°.07	+0°.03	−0°.04	−0°.06	−0°.03	−0°.04	−0°.09
Colon, Sweetwater, *B*...	1915.25	+36.0	.398	−0.02	+0.03	−0.30	−0.16	−0.06	−0.04	−0.18	−0.22
Honolulu Observatory, *A*.	1915.48	+39.5	.376	−0.08	−0.01	−0.33	−0.20	−0.07	−0.04	−0.18	−0.23
Dutch Harbor, *B*.......	1915.58	+66.3	.520	−0.07	−0.03	0.00	−0.10	−0.07	−0.04	−0.06	−0.11
Christchurch, *Brass Pipe*	1915.88	−68.1	.599	+0.08	+0.09	−0.09	−0.02	+0.09	+0.05	+0.03	+0.05
Do...............	1916.33	−68.1	.599	+0.14	+0.07	−0.01	−0.02				
Guam, Sumay, *A*.......	1916.57	+14.0	.360	+0.07	−0.05	−0.32	−0.49	−0.03	−0.03	−0.23	−0.26
Goat Island, *B*.........	1916.77	+62.1	.534	−0.08	−0.01	−0.03	−0.16	−0.07	−0.03	−0.07	−0.12
Pilar Observatory, *E*....	1917.24	−25.7	.282	0.00	−0.08	[3](+0.01)	+0.04	+0.08	+0.04	−0.21	−0.19
Do...............	1917.83	−25.7	.282	−0.05	−0.10	....	0.00				
Lima, *C*...............	1918.19	−00.8	.302	−0.04	+0.02	−0.21	−0.23	+0.01	−0.01	−0.27	−0.28
Cristobal, *A*...........	1918.34	+36.6	.400	−0.02	−0.02	−0.10	−0.22	−0.06	−0.04	−0.18	−0.22
Washington, N_e.........	1918.49	+71.1	.581	−0.10	−0.06	−0.07	−0.09	−0.06	−0.03	−0.04	−0.09

[1] All values are based on I.M.S.
[2] For the formulae adopted from least-square adjustments see Table 11.
[3] This value was interpolated from graph of ΔI.

Sea dip-circle 204.—Sea dip-circle 204, manufactured by Dover, is of the latest pattern (see p. 195, Vol. III, *Res. Dep. Terr. Mag.*). It was used during March 1915, Cruise IV, and the following adopted inclination corrections are the means of the values as determined by comparison observations at Washington and at Colon, except in the case of needle 9, which was broken at sea, en route to Colon: Needle 2, −0°.04; needle 9, −0°.05; needle 11, −0°.06; needle 7*D* and *R*, deflected by needle 8, short distance, −0°.26, long distance, −0°.21.

Marine earth-inductor 3.—Marine earth-inductor 3 was used on the *Carnegie* during cruises IV, V, and VI. This is the same instrument which was used during the earlier cruises. It was extensively overhauled and repaired in October 1916. The adopted inclination correction from all available data is, for cruises IV and V, for all values of inclination, −0°.01, using a marine moving-coil galvanometer.

During Cruise VI this instrument was fitted with a special coil provided with a slip ring, instead of a commutator, for use with the new string galvanometer. The adopted

inclination correction from all available data is, for Cruise VI, for all values of inclination, using string galvanometer, $-0\overset{\circ}{.}02$.

Marine earth-inductor 7.—Marine earth-inductor 7 was designed and constructed by the Department of Terrestrial Magnetism during 1917, and was used on board the *Carnegie* during Cruise VI. It is of similar design to inductor 3, with the exception of minor mechanical improvements. It is provided with the same type marine moving-coil galvanometer previously used on the *Carnegie* with inductor 3. The adopted inclination correction from all available data is, for all values of inclination, $0\overset{\circ}{.}00$.

TABLE 14.—*Inclination Corrections for Sea Dip-Circle 189, Determined at Shore Stations during Cruise VI.*

Station	Date	Magnetic elements		Observed ΔI[1]						Computed ΔI[2]					
				Regular dip needles		Needle 3,[3] *D* and *R*, deflected by needle 4		Needle 11, *D* and *R*, deflected by needle 12		Regular dip needles		Needle 3, *D* and *R*, deflected by needle 4		Needle 11, *D* and *R*, deflected by needle 12	
						Distance		Distance				Distance		Distance	
		I	*F*	1	2	Short	Long	Short	Long	1	2	Short	Long	Short	Long
		°	*c.g.s.*	°	°	°	°	°	°	°	°	°	°	°	°
Washington, *N*	1919.64	+71.2	0.580	−0.07	−0.02	−0.08	−0.10	−0.04	−0.01	−0.17	−0.11	−0.10	−0.11	−0.10	−0.08
Buenos Aires, Florida, *A*	1920.10	−27.9	0.278	+0.24	+0.06	[4](+0.09)	−0.02	......	......	−0.02	+0.06	−0.20	−0.22	......	......
Cape Town, Valkenberg, *A*	1920.34	−61.5	0.347	+0.30	+0.28	+0.09	−0.22	......	......	+0.28	+0.18	+0.16	−0.13	......	......
Colombo, *A*	1920.53	−04.2	0.385	−0.34	−0.07	−0.44	−0.28	......	......	−0.18	−0.04	−0.28	−0.18	......	......
Fremantle, Cottesloe, *A*	1920.70	−65.4	0.574	+0.28	+0.20	+0.10	−0.06	......	......	+0.19	+0.12	+0.13	−0.08	......	......
Christchurch, *Jarrah Peg*	1920.85	−68.2	0.599	+0.10	+0.08	+0.16	−0.07	......	......	+0.20	+0.12	+0.14	−0.07	......	......
Papeete, Fareute Point	1920.99	−31.0	0.378	......	......	......	......	−0.17	−0.17	......	......	......	......	−0.23	−0.24
San Francisco, Fort Scott, *B*	1921.18	+62.3	0.532	−0.28	−0.20	......	......	−0.12	−0.15	−0.21	−0.12	......	......	−0.11	−0.17
Honolulu Observatory, *A*	1921.30	+39.4	0.373	−0.17	+0.16	......	......	−0.15	−0.45	−0.32	−0.16	......	......	−0.17	−0.45
Apia Observatory, *B*	1921.55	−30.0	0.407	−0.11	−0.17	......	......	−0.26	−0.30	0.00	+0.05	......	......	−0.21	−0.23
Washington, *N*	1921.90	+71.2	0.578	−0.25	−0.25	......	......	−0.16	−0.16	−0.17	−0.11	......	......	−0.10	−0.08

[1] All values are based on I.M.S.
[2] For the formulae adopted from least-square adjustment, see Table 12.
[3] Pivot of needle 3 was broken on November 27, 1920. Needles 11 and 12 were used during the remainder of Cruise VI.
[4] This value was interpolated from mean of all shore-station data.

TOTAL-INTENSITY OBSERVATIONS.

Sea dip-circle 189.—The value of the horizontal intensity, *H*, is obtained by the formula

$$H = F \cos I$$

where *F* is the total intensity as observed with the sea dip-circle. As the method employed is a relative one, it is essential that no change be made in the weight used with the loaded-dip needle, and that its position be not shifted from one end of the needle to the other during a cruise; furthermore, the magnetism of the loaded-dip and deflected needles, except for the normal changes with time, must remain unchanged. The reduction formulae for the total intensity are:

Loaded-dip observations only, $F = C_l \cos I' \csc u$
Deflection observations only, $F = C_d \csc u_1$
Both loaded-dip and deflection observations, $F = C\sqrt{\cos I' \csc u \csc u_1}$

where I' is the loaded-dip angle, u_1 is the deflection angle, $u = I - I'$, C_l is the loaded-dip constant $= \dfrac{K}{m}$, C_d is the deflected-dip constant $= K_1 m$, and C is the combined constant $= \sqrt{KK_1}$. The constants C_l and C_d involve the magnetic moment, m, of the loaded-dip needle, and are both, therefore, subject to change with temperature and with time. C_l, furthermore, involves the induction correction, which is a function of F. C_d is affected also by changes in deflection distances, due to temperature changes, as well as by any

changes in the distribution coefficients. Two deflection distances, designated short (S) and long (L), are provided in the modified sea dip-circle, and thus there are two independent sets of constants. In deflection observations there are also two positions of the deflected or suspended magnet, designated "direct" (D) and "reversed" (R); "direct" position means that the face of the deflected needle is towards the face of the vertical circle; "reversed" position means that the face of the deflected needle is towards the back of the vertical circle. For all of the *Carnegie* work the deflection observations were made in both "direct" and "reversed" positions for each determination, and, therefore, the constants to be controlled by shore observations for that work are: C_l, C_{dDR} for S, and C_{dDR} for L. Values of these intensity constants were determined at each shore station and at Washington by means of comparisons between the sea dip-circles and standardized land magnetometers and inclination instruments.

Specimen observations and reductions for the determination of the constants are given on pages 248–250, Volume III. The specimens are typical of the compilations made for each pair of intensity needles. The order followed in the observations is such that the mean times of the three determinations of constants will be practically the same. The order is as follows: (1) loaded-dip observations, set I; (2) deflected-dip observations for "direct" position and short distance; (3) deflected-dip observations for "direct" position and long distance; (4) deflected-dip observations for "reversed" position and long distance; (5) deflected-dip observations for "reversed" position and short distance; and finally (6) loaded-dip observations, set II.

Because of the development of microscopic rust-pits on the needle pivots there are erratic changes in the intensity constants. It was, therefore, necessary to depend entirely upon graphical adjustments, or upon linear interpolations with time between shore-station values.

The adopted intensity constants, C_l, C_{dDRS}, C_{dDRL}, based on I.M.S. (see p. 35) for cruises IV and V are given in Table 15, and for Cruise VI are given in Table 16. These values are obtained by a direct time interpolation between the values as determined at the next preceding and the next following shore station. The values determined by comparison observations at shore stations were plotted and the values as given in Tables 15 and 16 were scaled directly from the straight-line graphs between successive shore-station values.

Values as computed by use of the general formula

$$F\Delta \log C = w + xt + y \sin I + z \cos I$$

did not agree with the observed values sufficiently well to warrant adoption.

Values as computed by use of the formula

$$\Delta \log C = xH + yZ$$

did not agree as well with observed values as those computed by use of the more general formula.

A comparison between the final H-values as observed with sea deflector 5, and those observed with sea dip-circle 189 at sea further confirmed the use of the straight-line interpolation adopted above. The adopted value of the temperature factor, q, is 0.0001 for both log C_l and log C_d. To refer a value at 20° centigrade, taken from Tables 15 and 16, to the temperature, t, of observations, the following formulae are used:

$$\log C_{lt} = \log C_{l20} - 0.0001(20° - t); \quad \log C_{dt} = \log C_{d20} + 0.0001(20° - t)$$

Sea dip-circle 204.—Sea dip-circle 204 was used on Cruise IV from New York to Colon. Owing to the breaking of the pivots of needles 8 and 9, this instrument was not used again at sea, but was retained as a reserve sea dip-circle.

TABLE 15.—*Intensity Constants at 20° Centigrade (C_{t20} and C_{d20}) for Sea Dip-Circle 189, Cruises IV and V.*

Date	Log C_{t20} for needle 4 loaded with weight 11	Log C_{d20} for needle 3 deflected by needle 4		Date	Log C_{t20} for needle 4 loaded with weight 11	Log C_{d20} for needle 3 deflected by needle 4	
		Short distance	Long distance			Short distance	Long distance
1915.28	9.4287	9.4515	9.3043	1916.54	9.4435	9.4466	9.2965
1915.30	9.4292	9.4513	9.3040	1916.60	9.4429	9.4460	9.2962
1915.35	9.4303	9.4509	9.3033	1916.65	9.4430	9.4450	9.2958
1915.38	9.4310	9.4507	9.3029	1916.70	9.4430	9.4438	9.2954
1915.50	9.4332	9.4495	9.3011	1916.73	9.4430	9.4434	9.2952
1915.54	9.4330	9.4488	9.3004	1916.84	9.4433	9.4425	9.2949
1915.59	9.4332	9.4480	9.2996	1916.90	9.4436	9.4429	9.2952
1915.65	9.4357	9.4477	9.2995	1916.95	9.4437	9.4433	9.2954
1915.70	9.4377	9.4474	9.2994	1917.00	9.4439	9.4436	9.2957
1915.75	9.4400	9.4471	9.2992	1917.05	9.4440	9.4440	9.2959
1915.80	9.4421	9.4468	9.2991	1917.10	9.4442	9.4443	9.2961
1915.84	9.4436	9.4466	9.2990	1917.16	9.4444	9.4447	9.2964
1915.93	9.4458	9.4463	9.2986				
1915.95	9.4459	9.4463	9.2985	1917.93	9.4456	9.4450	9.2964
1916.00	9.4460	9.4463	9.2982	1917.95	9.4457	9.4450	9.2964
1916.05	9.4463	9.4463	9.2980	1918.00	9.4461	9.4450	9.2965
1916.10	9.4465	9.4462	9.2977	1918.02	9.4464	9.4451	9.2965
1916.15	9.4467	9.4462	9.2974	1918.06	9.4467	9.4451	9.2966
1916.20	9.4469	9.4462	9.2972	1918.10	9.4470	9.4452	9.2966
1916.24	9.4471	9.4461	9.2970	1918.14	9.4474	9.4452	9.2967
1916.36	9.4468	9.4462	9.2965	1918.24	9.4463	9.4445	9.2963
1916.40	9.4461	9.4462	9.2965	1918.31	9.4447	9.4435	9.2959
1916.43	9.4456	9.4463	9.2965	1918.36	9.4439	9.4428	9.2953
1916.47	9.4448	9.4464	9.2965	1918.40	9.4449	9.4423	9.2942
1916.50	9.4442	9.4465	9.2965	1918.44	9.4460	9.4418	9.2930

TABLE 16.—*Intensity Constants at 20° Centigrade (C_{t20} and C_{d20}) for Sea Dip-Circle 189, Cruise VI.*

Date	Log C_{t20} for needle 4 loaded with weight 11	Log C_{d20} for needle 3 deflected by needle 4		Date	Log C_{t20} for needle 12 loaded with weight 11	Log C_{d20} for needle 11 deflected by needle 12	
		Short distance	Long distance			Short distance	Long distance
1919.78	9.4476	9.4407	9.2909	1920.90	9.3960	9.4854	9.3376
1919.80	9.4478	9.4409	9.2910	1920.95	9.3964	9.4856	9.3378
1919.85	9.4484	9.4411	9.2912	1920.97	9.3966	9.4856	9.3378
1919.90	9.4490	9.4414	9.2914	1921.01	9.3963	9.4851	9.3372
1919.95	9.4496	9.4417	9.2916	1921.05	9.3955	9.4839	9.3361
1920.00	9.4502	9.4419	9.2918	1921.10	9.3946	9.4824	9.3346
1920.04	9.4506	9.4421	9.2919	1921.13	9.3940	9.4815	9.3338
1920.15	9.4525	9.4422	9.2928	1921.24	9.3957	9.4802	9.3336
1920.20	9.4536	9.4420	9.2933	1921.27	9.3972	9.4803	9.3343
1920.26	9.4549	9.4418	9.2941	1921.33	9.3985	9.4808	9.3353
1920.31	9.4560	9.4416	9.2946	1921.35	9.3985	9.4811	9.3356
1920.38	9.4563	9.4410	9.2942	1921.40	9.3985	9.4819	9.3363
1920.40	9.4562	9.4408	9.2940	1921.46	9.3986	9.4828	9.3372
1920.45	9.4556	9.4403	9.2931	1921.57	9.3977	9.4836	9.3378
1920.49	9.4552	9.4398	9.2924	1921.60	9.3963	9.4828	9.3372
1920.56	9.4549	9.4388	9.2906	1921.65	9.3941	9.4816	9.3360
1920.60	9.4551	9.4380	9.2894	1921.70	9.3919	9.4805	9.3349
1920.66	9.4554	9.4367	9.2875	1921.76	9.3891	9.4790	9.3334
1920.76	9.4545	9.4355	9.2874	1921.80	9.3873	9.4780	9.3325
1920.80	9.4537	9.4354	9.2883	1921.86	9.3846	9.4766	9.3311
1920.88	9.4531	9.4350	9.2901				
1920.90	9.4534	9.4349	9.2905				

The adopted intensity constants, C_I, C_{dDRS}, C_{dDRL}, are given in Table 17. They are obtained by direct time interpolation between the values as determined at Washington and at Colon.

TABLE 17.—*Intensity Constants at 20° Centigrade (C_{I20} and C_{d20}) for Sea Dip-Circle 204.*

Date	Log C_{I20} for needle 8 loaded with weight 11	Log C_{d20} for needle 7 deflected by needle 8	
		Short distance	Long distance
1915.18........	9.5376	9.4505	9.3066
1915.19........	9.5372	9.4506	9.3068
1915.20........	9.5368	9.4506	9.3070
1915.21........	9.5364	9.4506	9.3072
1915.22........	9.5360	9.4507	9.3074

CONSTANTS AND CORRECTION FOR LAND INSTRUMENTS.

DESCRIPTIONS OF MAGNETOMETERS, MAGNETOMETER-INDUCTORS, AND EARTH INDUCTORS.

The reduction formulae and method of determining constants for the land instruments used in the *Carnegie* shore work and in the standardization of the ocean instruments during 1915–1921 were the same as those in Volume I (pp. 22–41). The types of magnetometers and earth inductor used at shore stations are described and illustrated in Volumes I (pp. 2–11), II (pp. 5–15), and III (pp. 196–200).

Magnetometer 5 was manufactured by the Bausch and Lomb Optical Company of Rochester, New York; the magnets are hollow cylinders, the large magnet being 7.5 cm. long, with inside diameter of 0.75 cm. and outside diameter of 1.00 cm., and the short magnet being 3.5 cm. long, with inside diameter of 0.61 cm. and outside diameter of 0.82 cm. Magnetometer-inductor 25 was designed and constructed by the Department of Terrestrial Magnetism; the magnets are hollow cylinders, the large magnet being 5.6 cm. long, with inside diameter of 0.60 cm. and outside diameter of 0.79 cm., and the short magnet being 2.6 cm. long, with inside diameter of 0.45 cm. and outside diameter of 0.65 cm. Phosphor-bronze-ribbon suspensions were used for these instruments. The details and constants for these magnetometers are given in Table 18.

TABLE 18.—*Details and Constants of Magnetometers Used, 1915–1921.*

(The C. G. S. system of units is used throughout the table; the value of q is given for 1° C.)

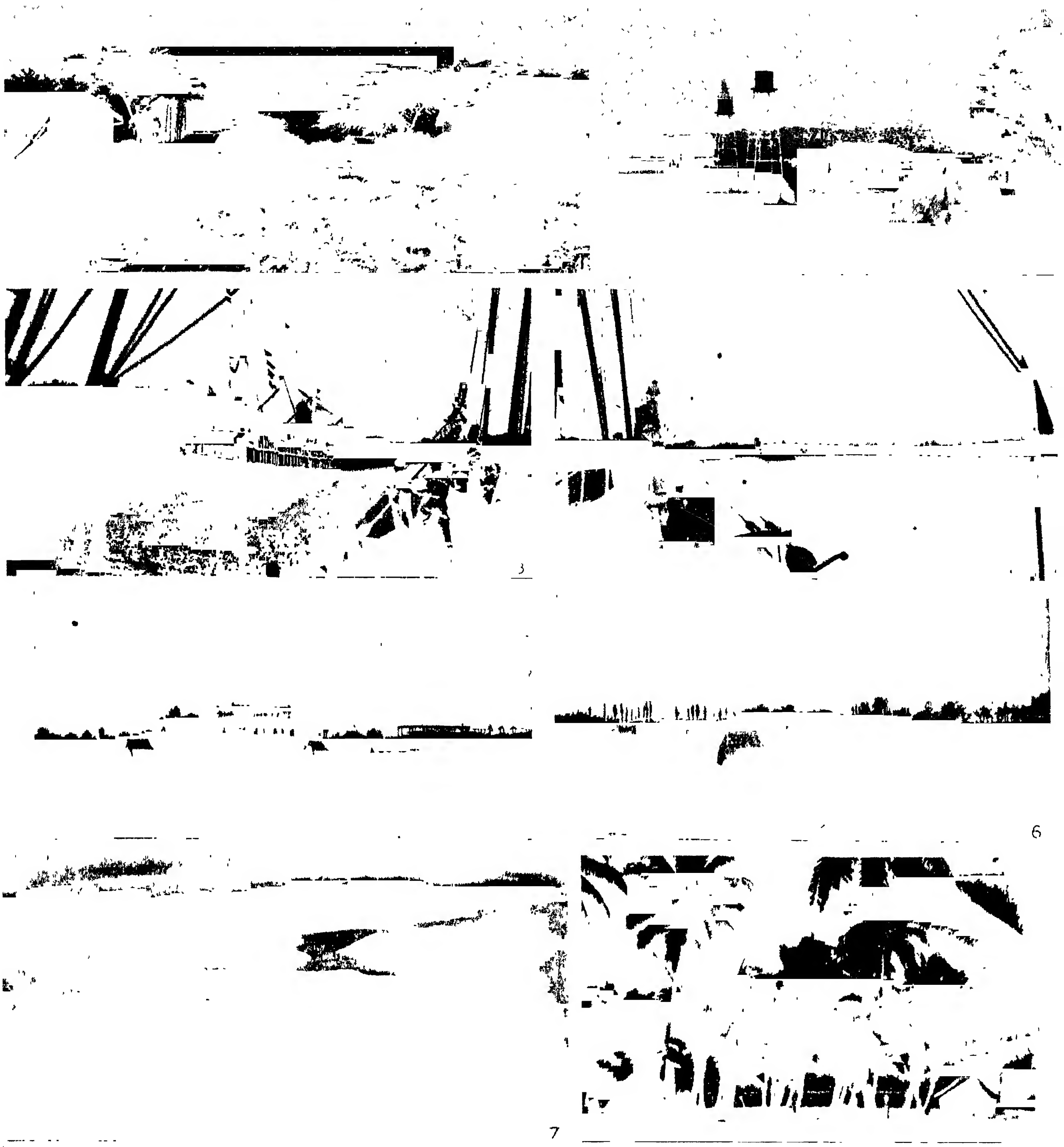
No.	Type	Diameter horizontal circle	Moments of long magnets at 20° C.		Logarithm of π^2K at 20° C.	Distribution coefficients[1]		Induction coefficient, h	Temperature coefficient, q	Scale value for declination	Deflection distances used
			Inertia	Magnetic		P	Q				
		cm.									*cm.*
3[2]	1 (*a*)	12.5	166	657	3.21487	+10.71	+1000	0.0088	0.00041	1'.49	25,27.5, 30,35,40
5[3]	1 (*a*)	12.5	234	610	3.36323	+14.07	....	0.0063	0.00051	1.48	25,27.5, 30,35,40
25[3]	4 (*c*)	10.2	65	304	[4]2.80408	+ 7.74	....	0.0093	0.00045	1.97	20,25,28

[1] When no values are entered for Q the values given for P are the values of P', assuming that $(1+P'r^{-2})=(1+Pr^{-2}+Qr^{-4})$; this implies that the theoretical condition, $Q=0$, holds, since the dimensions of magnets were selected accordingly.

[2] Magnetometer 3 is the standard magnetometer of the Department of Terrestrial Magnetism.

[3] Instrument overhauled and repaired during July 1919.

[4] Before overhauling of July 1919, value was 2.80522.



VIEWS OF LAND STATIONS, CRUISES IV AND V, AND OF PASSAGE THROUGH THE PANAMA CANAL.

1. Honolulu Magnetic Observatory, Honolulu, T. H.
2. Guam, Ladrone Islands.
3. Meeting steamer near Gaillard Cut, Panama Canal.
4. Approaching Gatun Locks, Panama Canal.
5. Hipodromo, Lima, Peru.
6. Magnetic observatory, Pilar, Argentina.
7. Magnetic station and the *Carnegie*, from Ballyhoo Mountain, Dutch Harbor, Alaska.
8. Magnetic observatory, Apia, Samoa.

The marine *earth-inductors*, type (*b*), as already described in this Volume (pp. 24–29) and in Volume III (pp. 196–200), were used also at shore stations. The earth-inductor attachment of magnetometer-inductor 25, type 4 (*c*), used at shore stations, is described in Volume II (pp. 13–15). Earth inductor 48 of the Wild-Edelmann pattern, constructed by Schulze, and fully described and illustrated in Volume I (pp. 10–11), is the standard inclination instrument of the Department of Terrestrial Magnetism.

MAGNETOMETER CORRECTIONS.

The corrections of each magnetometer on the adopted standard (see p. 35) were determined in Washington, before and after field use of the instrument and also in the field, wherever possible, by means of comparisons with other magnetometers. The accuracy of the mean corrections for the land instruments is usually about 0′.2 in declination, and about 0.0001H in horizontal intensity. The tabulated corrections are to be applied algebraically, east declination being recorded as positive and west declination as negative; horizontal intensity is always taken as positive.

The tabulated H-corrections shown in Table 19 are the equivalent corrections on the basis of the finally adopted constants as given in Table 18.

TABLE 19.—*Magnetometer Corrections on I.M.S.*[1] *for the Period 1915–1921.*

For Cruise	No. of magnetometer	Correction to observed: Declination	Correction to observed: Horizontal intensity[2]	Remarks
....	3	−0′.1	0.00000H	Standard magnetometer.
IV and V....	5	−0.9	−0.00054H	
VI..........	5	−0.2	[3]−0.00058H	After overhauling of July 1919.
IV and V....	25	−0.3	+0.00008H+0.00026(1914.22−t)H	
VI..........	25	[3]−0.2	[3]+0.00029H+0.00040(1920.00−t)H	After overhauling of July 1919.

[1] International Magnetic Standards as defined on p. 35.
[2] For remarks regarding variable H-corrections with time see Vol. IV, *Res. Dep. Terr. Mag.*, p. 10.
[3] These values supersede those published in Vol. IV, *Res. Dep. Terr. Mag.*, the latter being provisionally adopted before the completion of Cruise VI.

EARTH-INDUCTOR CORRECTIONS.

The numerous comparisons made with earth inductors by the observers of the Department of Terrestrial Magnetism, in various regions of the globe, have indicated that the correction of an earth inductor on standard is subject to practically no change with change in magnetic field. The adopted inclination corrections are given separately for each instrument; they are to be applied algebraically, inclination of the north-seeking end of the needle below the horizon being regarded as positive, and *vice versa.*

Marine earth-inductor 3.—Marine earth-inductor 3 was used at shore stations on cruises IV and V as a standard inclination instrument in conjunction with magnetometer-inductor 25. The adopted inclination correction is the same as that used for the sea work, viz, −0′.6.

Marine earth-inductor 7.—Marine earth-inductor 7 (see Pl. 3, Fig. 1) was used at shore stations on Cruise VI as a standard inclination instrument in conjunction with magnetometer-inductor 25. The adopted inclination correction is the same as that used for the sea work, viz, −0′.2.

Magnetometer-inductor 25.—The inductor attachment of magnetometer-inductor 25 was used at shore stations as a standard inclination instrument throughout cruises IV, V, and VI; the adopted inclination correction is 0′.0 for all three cruises.

OCEAN MAGNETIC OBSERVATIONS ON THE CARNEGIE, 1915–1921.

EXPLANATORY REMARKS FOR FINAL RESULTS, 1915–1921.

The same conventions have been followed in this volume as were adopted in the publication of the previous ocean results, Volume III, Researches of the Department of Terrestrial Magnetism, pages 257–295.

Stations.—It will be seen that the results are tabulated separately for each of the cruises of the *Carnegie*, and for each ocean. The parallel of 20° longitude east of Greenwhich has been adopted as the dividing-line between the Atlantic and Indian oceans, 147° east between the Indian and Pacific oceans, and 293° east between the Pacific and Atlantic oceans. Next under each cruise the stations or points at which the observations were made are arranged chronologically, and they are numbered accordingly. Thus, for Cruise IV, the stations are numbered beginning with 1 CIV (Station 1, *Carnegie* Cruise IV). Similarly for cruises V and VI.

Geographic positions.—The second and third columns contain, respectively, the latitude and longitude (counted east from Greenwich), expressed in degrees and the nearest minute of arc. The latitudes and longitudes for the points of observation at sea were determined in accordance with methods described for previous cruises; in general they may be regarded as correct within 2 or 3 nautical miles. The geographic positions of the harbor stations are in general known within 1′ of latitude and longitude.

Date.—The date on which the magnetic observations were made is recorded in the fourth column. The following abbreviations have been adopted for the months of the year: Jan, Feb, Mar, Apr, May, Jun, Jul, Aug, Sep, Oct, Nov, Dec. The year is indicated at the head of the column.

Magnetic elements.—The values of the magnetic elements (declination, inclination, and horizontal intensity) will be found in the next columns as observed at the local mean time (L.M.T.), expressed to the nearest 0.1 hour, opposite each value. Occasionally it has appeared desirable, where diurnal variation in declination was observed; as, for example, in connection with the shore results on pages 109 to 121, or where numerous observations were made during a certain interval, as during a vessel swing, to give the local mean times of the beginning and of the end of the series, and to indicate for land results the number of determinations from which the mean value is derived by a number inclosed in parentheses, thus, $9^h.1$ to $11^h.3$(7) is to be read "the mean is the result of 7 determinations made during the interval $9^h.1$ to $11^h.3$, local mean time, inclusive;" $6^h.1$ to $20^h.3$ (dv) is to be read "eye readings of the suspended magnet were made regularly at short intervals from $6^h.1$ to $20^h.3$, local mean time." The local mean times are given according to civil reckoning and are counted from midnight as zero hour continuously through 24 hours; 16^h, for example, means 4 o'clock p.m.

The ocean values of magnetic declination and of inclination are given in degrees and minutes of arc. No claim, however, is made that they are correct to a minute of arc. In general, the error in the tabulated value is about 5′ to 10′ or less; in some cases the error may be more, dependent upon the severity of the conditions encountered during the observations. It was thought best to retain the original quantities resulting from the computations until the various corrections, mentioned below, have been applied.

Only the mean quantities resulting from the observations with all instruments used for any particular element are given.

The values of the horizontal intensity, derived as described for previous cruises, with all instruments employed, are tabulated to the fourth decimal of the C. G. S. unit of magnetic field intensity. In magnetic-survey work on land the fourth decimal is often uncertain by one or more units, and in ocean work the error may be five or more units in this decimal place. It is thus to be understood that no claim is made for the correctness of the last figure; it has been retained here primarily in order that when all reductions to

common epoch have been applied on account of the various magnetic variations, the error of computation will be kept within the desired limit.

The question whether to give values of the horizontal intensity exclusively, or values of total intensity, was decided in the previous volumes, for the practical reasons there stated, in favor of the former.

The *instruments* used are shown in the columns "Compass" and "Dip circle." The designations of the various instruments employed will be found stated on pages 30 to 34. The term "Compass" also includes the "Sea deflector" with which both declinations and horizontal intensities were observed, as described on page 24. The term "Dip circle" also includes the "Marine earth-inductor" and the "Magnetometer-inductor" and the "Sea dip-circle" when arranged for measurement of the total intensity. The designation 189.12*34* means that inclination was observed with sea dip-circle 189, using regular dip needles 1 and 2 and deflected needle 3, and that, furthermore, total intensity was obtained by the deflection method, using intensity needles 3 and 4. Invariably the intensity needles are italicized and are given last. The higher number of the two intensity needles always designates the chief intensity needle (the deflecting and the loaded needle). Whenever the total intensity was determined from both loaded-dip observations and deflections, this fact is shown by the addition of the dagger (†); thus, *e. g.*, 189.12*34*†. For the latter part of Cruise VI, when intensity-pair 11 and 12 were used instead of intensity-pair 3 and 4, the needle numbers are separated by commas, thus, 189.1,2,*11*,*12*†. By referring to the specimens of observations, given in Volume III, pages 212–225, any additional explanation required may be obtained.

The columns of "Remarks" contain:

(*a*) *Course.*—This is the ship's magnetic course (heading), counting from 0° at north around through 90° at east, 180° at south, and 270° at west, on which the observations were made. To obtain true course, the declination for the day would have to be applied to the magnetic course as given. When the word "swing" occurs, this means that the vessel was swung during observations, to test occasionally the absence of deviation corrections. For all swings, the local mean times given in the respective columns denote the times of beginning and ending of the swing.

On the *Carnegie*, because of the absence of deviation corrections, it was also possible to make observations when the vessel's heading was shifting, as would be the case when the vessel was "becalmed" or "at anchor."

(*b*) *Roll.*—This column records the full angle through which the ship rolled, from side to side.

(*c*) *Sea.*—The state of the sea is indicated by the following symbols:

B. Broken or irregular sea.
C. Chopping, short, or cross sea.
G. Ground swell.
H. Heavy sea.
L. Long rolling sea.
M. Moderate sea, or swell.
R. Rough sea.
S. Smooth sea.
T. Tide rips.

(*d*) *Weather.*—The symbols denoting the state of the weather at the time are those in general use:

b. Clear, blue sky.
c. Clouds.
d. Drizzling or light rain.
f. Fog or foggy weather.
g. Gloomy, dark, stormy.
h. Hail.
l. Lightning.
m. Misty.
o. Overcast.
p. Passing showers.
q. Squally.
r. Rain.
s. Snow.
t. Thunder.
u. Ugly appearances, threatening weather.
v. Variable weather.
w. Wet or heavy dew.
z. Hazy weather.

Weights.—The figures given in the column marked "Wt." are the weights assigned the results on the following scale, which expresses, in a general way, the conditions (sea and weather) under which the observations were made: 1 denotes severe or adverse conditions, 2 medium, and 3 favorable conditions.

The application of variation corrections to the observed results on account of the numerous variations of the earth's magnetism, *e. g.*, diurnal variation, secular variation, magnetic perturbations, etc., is deferred to the volume in which all the magnetic data obtained both on land and sea are summarized and reduced to a common epoch. To avoid undue delay in the promulgation of the accumulated data it is considered best to publish the observed results as obtained with no corrections applied except the reductions to magnetic standards, as fully explained in the section on this subject (see pp. 35–47). However, since for the magnetic elements tabulated the precise date and local mean time of each observation are given, the reader is supplied with the required information in case, for some purpose of his own, he desires to reduce the observed values to some mean time.

COMBINING WEIGHTS ASSIGNED TO DIFFERENT INSTRUMENTS AND METHODS.

The tabulated values of the magnetic elements are the weighted means, usually of two or more results, obtained with two different instruments or by two different methods.

To obtain the weighted mean value of the declination, the results with the standard compass (marine collimating-compass C1) were given a combining weight 2, whereas the auxiliary results with sea deflector (D4, D5) received the weight 1, all conditions under which the observations were made being equal.

The weighted mean value of the inclination was obtained by assigning the weight 2 to the result from each dip needle and the weight 1 to the result derived from each completed observation of deflected dip. Hence, the inclination results from long and short distance each received a weight of 1, or if the observation at one distance was repeated, the result was given a weight of 2. At the stations where the inclination was determined both with the dip circle and the earth inductor, the dip-circle result, obtained as just described, was, in general, combined with the earth-inductor result by giving equal weights to the two instruments. When these two results differed by more than 0°.2, the dip circle was given weight 2 and the earth inductor weight 1. For results obtained with the new string galvanometer and earth inductor 3 during Cruise VI, one-half the foregoing weights was used. While the earth inductor on land gives results superior to those of the dip circle, certain difficulties enter in marine-inductor work which have not yet been entirely overcome.

The weighted mean value of the horizontal-intensity results was obtained by assigning weights 3, 2, and 1 to the sea-deflector results, the sea dip-circle results by deflections, and the sea dip-circle results by loaded needle, respectively, when the various results were obtained under normal sea conditions. But when the observations were made under unfavorable conditions of motion or with small values of horizontal intensity, the weights assigned were then 6, 4, 1, in the order designated. In some exceptional cases equal weights were assigned the results obtained by sea deflector and by sea dip-circle (deflected dip or loaded dip), as in the case of swings, exceptionally quiet conditions, etc.

The weights referred to above are not to be confused with the figures which appear in the "Wt." columns of the Table of Results. The tabular weights refer to the conditions as to sea and weather under which the observations were made (see p. 49).

DISTRIBUTION OF STATIONS.

Table 20 shows for each cruise (IV, V, and VI) of the *Carnegie* the number of days at sea, the length of the cruise in nautical miles, the number of tabulated values, respectively, of declination, inclination, and horizontal intensity; next the average time interval as well as the average distance apart between observations. For the total length of cruises IV to VI (140,713 nautical miles), the magnetic observations, whether of declination, inclination, or horizontal intensity, were made practically every day at an average distance apart of 70 to 131 miles. Plates 7, 8, 9, 10, and 11 show distribution of stations.

TABLE 20.—*Summary Showing the Distribution of the Carnegie Magnetic Observations, 1915–1921.*

Cruise	Number		Number of stations			Average time interval			Average distance apart		
	Days	Miles	Decl'n	Incl'n	Hor. int.	Decl'n	Incl'n	Hor. int.	Decl'n	Incl'n	Hor. int.
						d	*d*	*d*	*miles*	*miles*	*miles*
IV, 1915–17..	487	63,400	869	480	479	0.6	1.0	1.0	73	132	132
V, 1917–18..	122	13,195	224	116	116	0.5	1.1	1.1	59	114	114
VI, 1919–21..	487	64,118	834	439	439	0.6	1.1	1.1	77	146	146
IV, V, and VI.	1,096	140,713	1,927	1,035	1,034	0.6	1.1	1.1	70	131	131

OBSERVERS AND COMPUTERS.

In the Table of Ocean Results the observers' initials, for practical reasons, have been omitted. The magnetic results for any one day are the combined product of all the observers on board at the time. Those who took part in the observations for the various cruises are as follows:

Carnegie, Cruise IV.—J. P. Ault, H. M. W. Edmonds, H. F. Johnston (to April 1916), B. Jones (from April 1916), I. A. Luke (to October 1916), F. C. Loring (from November 1915 to October 1916), N. Meisenhelter, A. D. Power (from October 1916), H. E. Sawyer (to November 1915), and L. L. Tanguy (from October 1916).

Carnegie, Cruise V.—H. M. W. Edmonds, B. Jones, J. M. McFadden, A. D. Power, W. E. Scott, and L. L. Tanguy.

Carnegie, Cruise VI.—J. P. Ault, L. A. Bauer (from October 1921), F. A. Franke (from October 1921), H. R. Grummann, H. F. Johnston, R. R. Mills (to October 1921), R. Pemberton (to August 1921), and A. Thomson.

For the names of observers and computers for previous cruises, see Volume III, Researches of the Department of Terrestrial Magnetism, page 260.

The chief persons who have taken part, at various times, in the determination of instrumental constants and comparisons at Washington, in the final office reductions, or in the preparation of results for publication, of this volume, are: *J. P. Ault*, L. A. Bauer, J. J. Capello, C. R. Duvall, C. C. Ennis, *J. A. Fleming*, *H. F. Johnston*, W. J. Peters, and E. L. Tibbetts. Those whose names are italicized have borne the chief brunt of the work at Washington.

FINAL RESULTS OF OCEAN MAGNETIC OBSERVATIONS ON THE CARNEGIE, 1915–1921.

CRUISE IV, ATLANTIC OCEAN, 1915.

Station	Lat.	Long. East of Gr.	Date	Declination L. M. T.	Declination Value	Declination Wt.	Inclination L. M. T.	Inclination Value	Inclination Wt.	Hor. intensity L. M. T.	Hor. intensity Value	Hor. intensity Wt.	Instruments Compass	Instruments Dip Circle	Remarks Course	Remarks Roll	Remarks Sea	Weather
	° ′	° ′	1915	h h	° ′		h h	° ′		h h	c. g. s.				°	°		
0CIV	41 06 N	287 47	Mar 7				12.2 to 17.0	72 10 N	3	12.2 to 17.0	0.1803	3	D4	204.278	Swing	7	MS	c
	(Gardiners Bay)		Mar 8	15.0 to 17.9	12 03 W	3	8.0 to 14.2	72 11 N	3	8.0 to 14.2	.1800	3	C1, D4	204.978	Swing	0	S	c
1CIV	40 38 N	288 12	Mar 9				15.6	72 01 N	2	15.6	.1801	2	D4	204.2978†	191	15	M	bc
2CIV	40 23 N	288 12	Do.	17.3	11 18 W	3							C1, D4		191	15	M	b
3CIV[1]	37 48 N	288 15	Mar 10	8.2	9 22 W	2							C1, D4		191	17	MR	bc
4CIV[2]	36 37 N	288 26	Do.				15.0	69 11 N	1	15.0	.2033	1	D4	EI3,204.2978†	191	30	R	c
6CIV	34 17 N	288 33	Mar 11	7.6	7 28 W	1							C1, D4		191	39	R	bc
7CIV	33 20 N	288 26	Do.				15.0	66 19 N	1	14.9	.2236	1	D4	EI3,204.2978†	197	32	R	bc
8CIV	33 05 N	288 25	Do.	17.0	6 45 W	1							C1, D4		197	30	R	bc
9CIV	31 28 N	288 19	Mar 12	6.6	5 50 W	3							C1, D4		197	14	M	bc
10CIV	30 25 N	288 06	Do.				14.8	63 19 N	1	14.8	.2424	1	D4	EI3,204.2978†	202	22	M	bc
11CIV	30 09 N	288 01	Do.	17.1	4 50 W	3							C1, D4		202	22	M	bc
12CIV	28 26 N	288 27	Mar 13	7.2	4 15 W	3							C1, D4		158	36	M	bc
13CIV	27 38 N	288 53	Do.				14.4	60 40 N	2	14.4	.2552	2	D4	EI3,204.2978†	158	26	M	bc
14CIV	27 23 N	289 00	Do.	17.1	4 07 W	1							C1		158	26	M	bc
15CIV	26 28 N	289 19	Mar 14				14.6	59 32 N	3	14.5	.2599	3	D4	EI3,204.2978†	45	11	S	c
16CIV	24 44 N	289 58	Mar 15	6.9	3 39 W	3							C1, D4		158	14	M	bc
17CIV	23 46 N	290 34	Do.				14.4	56 55 N	2	14.4	.2683	2	D4	EI3,204.2978†	152	12	M	bc
18CIV	23 29 N	290 43	Do.	17.4	2 38 W	3							C1, D4		152	30	M	bc
19CIV	23 01 N	290 48	Mar 16	6.3	2 35 W	3							C1, D4		214	10	S	b
20CIV	22 54 N	290 49	Do.				14.2	55 48 N	3	14.2	.2729	3	D4	EI3,204.2978†	79	7	S	c
21CIV	22 53 N	291 08	Do.	17.4	3 17 W	3							C1, D4		112	10	M	bc
22CIV	22 36 N	292 33	Mar 17	6.4	4 10 W	3							C1, D4		141	8	M	bc
23CIV	22 02 N	293 14	Do.				14.6	55 11 N	2	14.6	.2721	2	D4	EI3,204.2978†	146	8	M	bc
24CIV	21 50 N	293 23	Do.	17.3	4 14 W	3							C1, D4		146	8	S	bc
25CIV	20 57 N	293 21	Mar 18	8.4	3 56 W	2							C1, D4		202	6	S	bc
26CIV	20 23 N	293 08	Do.				14.4	53 08 N	3	14.4	.2805	3	D4	EI3,204.278†	202	12	S	c
27CIV	18 43 N	292 13	Mar 19	6.3	3 17 W	3							C1, D4		236	12	S	bc
28CIV	18 00 N	291 28	Do.				14.5	50 14 N	2	14.5	.2907	2	D4	EI3,204.278†	234	12	M	bc
29CIV	17 46 N	291 07	Do.	17.4	1 34 W	3							C1, D4		230	12	M	bc
30CIV	17 04 N	289 57	Mar 20	6.5	0 54 W	3							C1, D4		228	27	S	bc
31CIV	16 42 N	289 20	Do.				14.4	48 22 N	2	14.4	.2941	2	D4	EI3,204.21178†	231	27	S	b
32CIV	16 31 N	289 03	Do.	17.6	0 11 W	3							C1, D4		232	13	M	bc
33CIV	15 37 N	287 44	Mar 21	6.4	0 43 E	3							C1, D4		225	13	M	bc
34CIV	15 04 N	286 57	Do.				14.6	45 49 N	2	14.6	.3017	2	D4	EI3,204.21178†	232	13	MS	b
35CIV	14 52 N	286 37	Do.	17.8	1 16 E	3							C1, D4		232	13	M	bc
36CIV	13 53 N	285 10	Mar 22	6.8	1 59 E	3							C1, D4		225	9	M	bc
37CIV	13 20 N	284 24	Do.				14.4	42 37 N	3	14.4	.3122	3	D4	EI3,204.21178†	232	19	S	bc
38CIV	12 17 N	282 51	Mar 23	8.8	3 11 E	2							C1, D4		230	6	S	bc
39CIV	11 55 N	282 18	Do.				14.5	40 29 N	3	14.5	.3143	3	D4	204.21178†	225	6	S	bc
40CIV	11 51 N	282 12	Do.				15.7	40 13 N	3					EI3	225	6	S	c
41CIV	11 44 N	282 02	Do.	17.9	3 50 E	1							C1		225	6	S	c
42CIV	10 51 N	280 48	Mar 24	6.6	4 10 E	3							C1, D4		225	9	S	bc
43CIV[3]	10 41 N	280 19	Do.				14.8	38 04 N	2	14.8	.3204	2	D4	EI3,204.21178†	191	29	R	c

[1] Mean of four positions. [2] Station 5CIV rejected. [3] From March 24 to April 12 the *Carnegie* was at Cristobal and Balboa.

CRUISE IV, PACIFIC OCEAN, 1915.

	° ′	° ′	1915	h	h	° ′		h	h	° ′		h	h	c. g. s.				°	°		
44CIV	8 34 N	280 30	Apr 12	....	....	....	..	14.2	....	34 56 N	3	14.2	....	0.3216	3	D4	189.1234†	180	1	S	bo
45CIV	8 21 N	280 28	Do.	17.5	....	4 40 E	3	....	....	....	..	....	....	......	..	C1, D4	....	180	2	S	b
46CIV	6 20 N	279 49	Apr 13	....	....	....	..	14.3	....	30 54 N	3	14.4	....	.3257	3	D4	189.1234†	225	2	S	bo
47CIV	6 16 N	279 48	Do.	17.2	....	5 14 E	3	....	....	....	..	....	....	......	..	C1, D4	....	225	1	S	bo
48CIV	5 50 N	279 47	Do.	7.0	....	5 38 E	3	....	....	....	..	....	....	......	..	C1, D4	....	225	5	S	bo
49CIV	5 16 N	279 41	Do.	....	....	....	..	14.8	....	29 02 N	3	14.8	....	.3254	3	D4	189.1234†	174	3	S	bo
50CIV	5 07 N	279 39	Apr 14	16.9	....	5 22 E	3	....	....	....	..	....	....	......	..	C1, D4	....	174	5	S	bo
51CIV[1]	4 18 N	279 34	Apr 15	6.4 to	7.6	5 43 E	3	....	....	....	..	....	....	......	..	C1, D4	....	Swing	2	S	bo
52CIV[1]	4 08 N	279 35	Do.	....	....	....	..	8.4 to	11.0	26 58 N	3	8.4 to	11.0	.3261	3	D4	189.1234†	Swing	2	S	bo
53CIV	3 36 N	279 13	Do.	17.4	....	5 56 E	3	....	....	....	..	....	....	......	..	C1, D4	....	225	8	S	bo
54CIV	2 52 N	278 32	Apr 16	6.3	....	6 31 E	3	....	....	....	..	....	....	......	..	C1, D4	....	202	7	S	bo
55CIV	2 28 N	277 59	Do.	....	....	....	..	14.0	....	23 42 N	3	14.2	....	.3260	3	D4	189.1234†	236	4	S	bo
56CIV	2 18 N	277 47	Do.	17.4	....	6 40 E	3	....	....	....	..	....	....	......	..	C1, D4	....	236	6	S	bo
57CIV	2 08 N	277 00	Apr 17	6.6	....	6 50 E	3	....	....	....	..	....	....	......	..	C1, D4	....	236	6	S	bo
58CIV	2 09 N	275 57	Do.	....	....	....	..	14.5	....	22 24 N	2	14.5	....	.3284	2	D4	189.1234†	264	10	M	bo
59CIV	2 10 N	275 35	Do.	17.3	....	7 08 E	3	....	....	....	..	....	....	......	..	C1, D4	....	292	14	M	bo
60CIV	2 19 N	274 19	Apr 18	6.3	....	7 28 E	3	....	....	....	..	....	....	......	..	C1, D4	....	236	9	M	bo
61CIV	2 25 N	273 32	Do.	....	....	....	..	13.9	....	21 35 N	3	13.9	....	.3320	3	D4	189.1234†	259	8	MS	bo
62CIV	2 22 N	273 15	Do.	17.0	....	7 32 E	3	....	....	....	..	....	....	......	..	C1, D4	....	253	8	M	bo
63CIV	2 11 N	272 20	Apr 19	6.3	....	7 59 E	3	....	....	....	..	....	....	......	..	C1, D4	....	236	6	S	bo
64CIV	2 07 N	271 37	Do.	....	....	....	..	14.9	....	20 30 N	3	14.9	....	.3337	3	D4	EI3,189.1234†	253	8	M	bo
65CIV	2 04 N	271 23	Do.	17.0	....	7 54 E	3	....	....	....	..	....	....	......	..	C1, D4	....	259	12	S	bo
66CIV	2 01 N	270 08	Apr 20	6.4	....	8 29 E	3	....	....	....	..	....	....	......	..	C1, D4	....	270	6	S	bo
67CIV	2 15 N	269 14	Do.	....	....	....	..	14.6	....	19 35 N	3	14.7	....	.3356	3	D4	EI3,189.1234†	276	6	M	bo
68CIV	2 20 N	268 59	Do.	16.9	....	8 20 E	3	....	....	....	..	....	....	......	..	C1, D4	....	287	6	S	bo
69CIV	2 53 N	267 48	Apr 21	7.3	....	8 31 E	2	....	....	....	..	....	....	......	..	C1, D4	....	281	6	S	bo
70CIV	2 59 N	266 55	Do.	....	....	....	..	14.8	....	19 41 N	3	14.8	....	.3394	3	D4	EI3,189.1234†	259	6	S	bo
71CIV	3 02 N	266 38	Do.	17.1	....	8 32 E	2	....	....	....	..	....	....	......	..	C1	....	287	6	S	bo
72CIV	3 21 N	264 53	Apr 22	8.3	....	8 44 E	2	....	....	....	..	....	....	......	..	C1, D4	....	287	6	S	bo
73CIV	3 57 N	264 23	Do.	....	....	....	..	14.8	....	21 07 N	3	14.8	....	.3387	3	D4	EI3,189.1234†	326	2	S	o
74CIV	4 09 N	264 19	Do.	17.7	....	8 55 E	2	....	....	....	..	....	....	......	..	C1, D4	....	310	4	S	bo
75CIV	4 41 N	264 00	Apr 23	9.2	....	8 29 E	1	....	....	....	..	....	....	......	..	C1	....	315	3	S	bo
76CIV	5 04 N	263 47	Do.	....	....	....	..	14.1	....	22 59 N	3	14.0	....	.3401	3	D4	EI3,189.1234†	315	3	S	bo
77CIV	5 12 N	263 43	Do.	17.2	....	8 37 E	3	....	....	....	..	....	....	......	..	C1, D4	....	158	3	S	bo
78CIV	4 35 N	263 56	Apr 24	7.6	....	8 46 E	2	....	....	....	..	....	....	......	..	C1, D4	....	191	5	S	bo
79CIV	4 26 N	263 53	Do.	....	....	....	..	14.9	....	21 49 N	2	14.9	....	.3397	2	D4	EI3,189.1234†	169	9	S	bc
80CIV	4 22 N	263 54	Do.	17.2	....	8 41 E	1	....	....	....	..	....	....	......	..	C1	....	124	6	M	c
81CIV	3 49 N	264 38	Apr 25	7.2	....	8 37 E	3	....	....	....	..	....	....	......	..	C1, D4	....	107	4	S	bo
82CIV	3 50 N	264 33	Do.	....	....	....	..	14.2	....	21 01 N	3	14.2	....	.3386	3	D4	EI3,189.1234†	292	6	S	c
83CIV	3 52 N	264 25	Do.	17.3	....	8 41 E	3	....	....	....	..	....	....	......	..	C1, D4	....	287	6	S	bo
84CIV	4 12 N	263 39	Apr 26	7.8	....	8 46 E	2	....	....	....	..	....	....	......	..	C1, D4	....	349	10	S	bo
85CIV	4 13 N	263 33	Do.	....	....	....	..	14.6	....	21 20 N	3	14.6	....	.3402	3	D4	EI3,189.1234†	158	3	S	oo
86CIV	4 13 N	263 34	Do.	17.7	....	8 51 E	3	....	....	....	..	....	....	......	..	C1, D4	....	354	3	S	bo
87CIV	4 56 N	262 07	Apr 27	....	....	....	..	14.3	....	22 07 N	3	14.4	....	.3401	3	D4	EI3,189.1234†	135	7	S	oo
88CIV	5 13 N	261 49	Do.	19.6	....	8 38 E	2	....	....	....	..	....	....	......	..	C1	....	304	7	S	bo
89CIV	6 03 N	261 31	Apr 28	6.5	....	8 49 E	3	....	....	....	..	....	....	......	..	C1, D4	....	315	8	S	bo
90CIV	6 37 N	261 07	Do.	....	....	....	..	14.5	....	25 05 N	2	14.5	....	.3416	2	D4	EI3,189.1234†	281	6	M	or
91CIV	7 47 N	260 38	Apr 29	6.4	....	8 40 E	3	....	....	....	..	....	....	......	..	C1, D4	....	338	4	M	bo
92CIV	8 18 N	260 39	Do.	....	....	....	..	14.5	....	27 38 N	3	14.5	....	.3422	3	D4	EI3,189.1234†	0	5	S	bo
93CIV	8 20 N	260 41	Do.	16.9	....	8 56 E	3	....	....	....	..	....	....	......	..	C1, D4	....	292	7	S	bo
94CIV	8 22 N	260 11	Apr 30	6.0	....	8 47 E	3	....	....	....	..	....	....	......	..	C1, D4	....	298	5	S	bo
95CIV	8 29 N	259 33	Do.	....	....	....	..	14.2	....	27 45 N	3	14.2	....	.3414	3	D4	EI3,189.1234†	276	11	M	bo
96CIV	8 30 N	259 26	Do.	16.1	....	8 37 E	2	....	....	....	..	....	....	......	..	C1, D4	....	338	7	M	bo
97CIV	8 29 N	258 26	May 1	6.3	....	9 07 E	3	....	....	....	..	....	....	......	..	C1, D4	....	338	21	M	bo
98CIV	8 44 N	257 38	Do.	....	....	....	..	14.2	....	27 36 N	2	14.2	....	.3403	2	D4	EI3,189.1234†	288	11	M	bo

[1] Swinging ship at sea.

FINAL RESULTS OF OCEAN MAGNETIC OBSERVATIONS ON THE CARNEGIE, 1915–1921—*Continued.*

CRUISE IV, PACIFIC OCEAN, 1915—*Continued.*

Station	Lat.	Long. East of Gr.	Date	Declination L. M. T.		Declination Value	Wt.	Inclination L. M. T.		Inclination Value	Wt.	Hor. intensity L. M. T.		Hor. intensity Value	Wt.	Instruments Compass	Instruments Dip Circle	Remarks Course	Roll	Sea	Weather
	° ′	° ′	1915	h	h	° ′		h	h	° ′		h	h	c. g. s.				°	°		
205CIV	56 37 N	192 27	Aug 6					15.4		68 16 N	2	15.4		0.1960	2	D4	EI3,189.1234†	349	13	M	o
206CIV	57 24 N	193 05	Aug 7					14.9		69 22 N	2	14.9		.1887	2	D4	EI3,189.1234†	298	10	S	oh
207CIV	57 37 N	193 02	Do.	17.2		16 23 E	2									C1, D4		349	2	M	o
208CIV	58 07 N	193 12	Aug 8	8.0		16 22 E	1									C1		242	17	R	o
209CIV	58 00 N	192 04	Do.					14.1		69 43 N	1	14.2		.1842	1	D4	189.1234†	252	17	R	o
210CIV	57 55 N	191 38	Do.	16.6		15 08 E	2									C1, D4		202	23	R	bc
211CIV	57 53 N	191 26	Do.	18.6		14 44 E	2									C1, D4		248	16	MR	bc
212CIV	57 40 N	190 59	Aug 9	4.4		15 19 E	2									C1, D4		202	10	S	bc
213CIV	58 12 N	189 46	Do.					15.2		70 05 N	1	15.2		.1855	2	D4	EI3,189.1234†	287	12	M	or
214CIV	59 05 N	188 31	Aug 10	5.6		15 23 E	2									C1, D4		281	18	R	bc
215CIV	59 02 N	187 36	Do.					15.1		69 49 N	2	15.1		.1846	2	D4	EI3,189.1234†	214–191	14	M	bc
216CIV	59 01 N	187 36	Do.	15.1		13 30 E	2									C1		191	17	MR	bc
217CIV	59 26 N	187 20	Aug 11	8.3		12 34 E	2									C1, D4		281	10	M	bq
218CIV	59 33 N	186 33	Do.					14.8		70 13 N	2	14.8		.1818	2	D4	EI3,189.1234†	270	5	M	o
219CIV	59 29 N	186 00	Do.	17.7		11 26 E	2									C1, D4		208	10	R	bc
220CIV	59 01 N	183 43	Aug 12	6.8		11 35 E	2									C1, D4		225	22	R	bc
221CIV	58 42 N	182 36	Do.					14.8		69 28 N	1	14.7		.1878	2	D4	EI3,189.1234†	236	13	M	bc
222CIV	58 36 N	182 21	Do.	16.8		9 23 E	2									C1, D4		214	10	MC	bc
223CIV	58 30 N	182 02	Do.	18.8		10 12 E	2									C1, D4		236	10	M	bc
224CIV	57 49 N	180 18	Aug 13	4.6		9 12 E	3									C1, D4		214	9	M	b
225CIV	57 02 N	178 49	Do.					14.4		67 56 N	2	14.4		.1973	2	D4	EI3,189.1234†	225	7	MS	o
226CIV	56 57 N	178 36	Do.	16.0		7 37 E	3									C1, D4		191	8	MS	bc
227CIV[1]	56 44 N	177 05	Aug 15	5.0		6 43 E	2									C1, D4		270,225	10	MS	bc
228CIV[2]	56 37 N	176 59	Do.					5.6 to 16.9		67 17 N	2	5.9 to 16.6		.2015	2	D4	189.1234†	Swing	10	M	bc
229CIV[2]	56 28 N	177 02	Do.	17.2 to 19.2		6 53 E	3									C1, D4		Swing	10	M	bc
230CIV	55 49 N	175 37	Aug 16	5.0		6 05 E	3									C1, D4		191	10	M	b
231CIV	55 36 N	175 13	Do.					14.4		66 20 N	3	14.4		.2074	3	D4	189.1234†	219	8	S	bc
232CIV	55 28 N	174 01	Do.	16.8		4 50 E	3									C1, D4		219	4	S	s
233CIV	54 35 N	173 21	Aug 17	5.4		4 40 E	3									C1, D4		219	10	M	bc
234CIV	53 46 N	172 05	Do.					14.2		64 43 N	2	14.2		.2169	2	D4	189.1234†	197	12	R	bc
235CIV	53 35 N	171 55	Do.	17.3		3 44 E	2									C1, D4		198	15	R	bc
236CIV	52 22 N	170 18	Aug 18	7.3		3 20 E	2									C1		198	25	R	f
237CIV	51 35 N	169 39	Do.					14.2		63 05 N	1	14.2		.2251	1	D4	189.1234†	191	25	R	f
238CIV	51 13 N	168 37	Aug 19	7.0		2 10 E	1									C1, D4		270,259	18	R	f
239CIV	51 14 N	168 28	Do.					15.2		62 10 N	2	15.2		.2314	2	D4	189.1234†	180	22	M	d
240CIV	49 46 N	168 16	Aug 20	8.3		1 58 E	2									C1, D4		180	13	M	fm
241CIV	49 12 N	168 21	Do.					15.6		60 29 N	2	15.4		.2370	2	D4	EI3,189.1234†	180	23	M	o
242CIV	48 14 N	168 22	Aug 21	10.1		1 44 E	1									C1		180	18	MS	o
243CIV	48 13 N	168 17	Do.					15.1		60 22 N	2	15.1		.2384	2	D4	EI3,189.1234†	219	18	MSL	o
244CIV	48 04 N	167 43	Do.	21.5		2 08 E	2									C1		231	14	M	bc
245CIV	47 27 N	166 45	Aug 22	6.4		1 39 E	2									C1, D4		191	8	S	bc
246CIV	46 46 N	166 03	Do.					14.6		58 25 N	3	14.6		.2459	3	D4	EI3,189.1234†	214	10	S	bc
247CIV	46 39 N	165 52	Do.	17.2		1 13 E	3									C1, D4		225	10	S	bc
248CIV	45 48 N	164 43	Aug 23	7.0		0 45 E	1									C1		191	4	M	oo
249CIV	45 20 N	164 07	Do.					14.6		57 22 N	3	14.6		.2484	3	D4	EI3,189.1234†	242	5	MS	bc
250CIV	45 20 N	164 00	Do.	16.3		0 44 E	3									C1, D4		292	9	S	bc
251CIV	45 00 N	163 18	Aug 24	7.4		0 45 E	3									C1, D4		236	4	S	bc
252CIV	44 45 N	162 54	Do.					14.4		57 41 N	2	14.4		.2522	3	D4	EI3,189.1234†	214	3	S	o

[1] August 14 omitted on crossing 180th meridian [2] Swinging ship at sea.

CRUISE IV, PACIFIC OCEAN, 1915—*Continued.*

	° ′	° ′	*1915*	h	h	° ′		h	h	° ′		h	h	c.g.s.				°	°		
253CIV	44 38 N	162 48	Aug 24	16.5	....	0 21 E	2	....	....	....	..	....	....	......	..	C1, D4	....	202	6	S	o
254CIV	44 32 N	162 49	Aug 25	6.5	....	0 10 E	3	....	....	....	..	....	....	......	..	C1, D4	....	68	6	S	bc
255CIV	44 29 N	163 12	Do.	....	....	....	..	14.5	....	56 03 N	3	14.5	....	0.2564	3	D4	EI3,189.1234†	214	8	MS	bc
256CIV	44 21 N	163 10	Do.	16.2	....	0 23 E	2	....	....	....	..	....	....	......	..	C1	....	180	4	S	bc
257CIV	41 19 N	163 30	Aug 26	....	....	....	..	14.8	....	53 19 N	2	14.8	....	.2623	2	D4	EI3,189.1234†	169	20	R	o
258CIV	40 33 N	163 35	Do.	20.2	....	1 10 E	1	....	....	....	..	....	....	......	..	C1	....	169	16	M	bc
259CIV	39 31 N	163 49	Aug 27	6.3	....	1 48 E	3	....	....	....	..	....	....	......	..	C1, D4	....	169	6	M	bc
260CIV	38 30 N	164 09	Do.	....	....	....	..	14.9	....	50 32 N	2	14.9	....	.2685	2	D4	EI3,189.1234†	172	9	MS	bc
261CIV	38 15 N	164 13	Do.	16.5	....	2 11 E	2	....	....	....	..	....	....	......	..	C1, D4	....	172	6	M	bc
262CIV	37 50 N	164 16	Do.	20.4	....	2 05 E	2	....	....	....	..	....	....	......	..	C1	....	172	11	M	bc
263CIV	36 51 N	164 28	Aug 28	7.1	....	2 23 E	3	....	....	....	..	....	....	......	..	C1, D4	....	166	10	MS	bc
264CIV	36 23 N	165 09	Do.	....	....	....	..	14.8	....	48 13 N	2	14.8	....	.2745	2	D4	EI3,189.1234†	135	10	M	bc
265CIV	36 08 N	165 25	Do.	17.8	....	3 05 E	2	....	....	....	..	....	....	......	..	C1, D4	....	146	15	S	bc
266CIV	35 13 N	166 42	Aug 29	6.3	....	3 57 E	2	....	....	....	..	....	....	......	..	C1, D4	....	141	17	M	bc
267CIV	34 55 N	167 47	Do.	....	....	....	..	14.7	....	46 55 N	2	14.7	....	.2750	2	D4	EI3,189.1234†	107	7	SL	bc
268CIV	34 54 N	168 07	Do.	16.9	....	4 13 E	2	....	....	....	..	....	....	......	..	C1, D4	....	93	9	MS	bc
269CIV	34 26 N	169 44	Aug 30	6.4	....	5 29 E	2	....	....	....	..	....	....	......	..	C1, D4	....	169	12	MC	bc
270CIV	33 33 N	170 19	Do.	....	....	....	..	14.9	....	45 48 N	2	14.8	....	.2741	2	D4	EI3,189.1234†	138	5	R	bc
271CIV	33 24 N	170 29	Do.	16.4	....	5 37 E	2	....	....	....	..	....	....	......	..	C1, D4	....	141	6	M	bc
272CIV	32 16 N	170 48	Aug 31	6.8	....	6 07 E	2	....	....	....	..	....	....	......	..	C1, D4	....	180	7	M	bc
273CIV	31 34 N	171 04	Do.	....	....	....	..	14.5	....	44 01 N	2	14.5	....	.2767	2	D4	EI3,189.1234†	164	3	MS	bc
274CIV	31 13 N	171 10	Do.	17.4	....	6 18 E	2	....	....	....	..	....	....	......	..	C1, D4	....	169	6	MS	bc
275CIV	30 28 N	171 18	Sep 1	6.0	....	6 43 E	3	....	....	....	..	....	....	......	..	C1, D4	....	191	7	S	bc
276CIV	30 03 N	171 06	Do.	....	....	....	..	15.4	....	42 11 N	2	15.3	....	.2807	2	D4	EI3,189.1234†	202	20	SL	bc
277CIV	30 02 N	171 06	Do.	16.3	....	6 53 E	2	....	....	....	..	....	....	......	..	C1	....	202	20	M	bc
278CIV	29 18 N	170 42	Sep 2	6.2	....	6 31 E	2	....	....	....	..	....	....	......	..	C1, D4	....	202	22	M	bc
279CIV	29 06 N	170 39	Do.	....	....	....	..	14.6	....	40 55 N	2	14.5	....	.2827	2	D4	EI3,189.1234†	202	20	SL	bc
280CIV	28 57 N	170 35	Do.	17.7	....	6 23 E	3	....	....	....	..	....	....	......	..	C1, D4	....	202	10	S	bc
281CIV	28 39 N	170 16	Sep 3	6.0	....	6 45 E	3	....	....	....	..	....	....	......	..	C1, D4	....	202	11	S	bc
282CIV	28 10 N	170 05	Do.	....	....	....	..	14.6	....	39 56 N	2	14.6	....	.2861	3	D4	EI3,189.1234†	180	10	S	bc
283CIV	27 59 N	170 04	Do.	17.5	....	6 22 E	3	....	....	....	..	....	....	......	..	C1, D4	....	180	10	M	bc
284CIV	27 41 N	170 01	Do.	20.5	....	6 35 E	2	....	....	....	..	....	....	......	..	C1	....	188	7	M	bc
285CIV	27 17 N	169 49	Sep 4	0.4	....	6 36 E	2	....	....	....	..	....	....	......	..	C1	....	188	6	M	bc
286CIV	26 44 N	169 23	Do.	6.4	....	6 24 E	2	....	....	....	..	....	....	......	..	C1, D4	....	202	23	M	bc
287CIV	25 50 N	168 43	Do.	....	....	....	..	14.6	....	36 34 N	2	14.6	....	.2918	2	D4	EI3,189.1234†	202	17	M	bc
288CIV	25 37 N	168 35	Do.	16.1	....	6 23 E	2	....	....	....	..	....	....	......	..	C1	....	202	16	M	o
289CIV	23 19 N	167 30	Sep 5	7.2	....	6 30 E	2	....	....	....	..	....	....	......	..	C1	....	188	20	MR	bc
290CIV	22 09 N	167 06	Do.	....	....	....	..	14.9	....	31 56 N	2	14.9	....	.3009	2	D4	EI3,189.1234†	191	20	R	oqr
291CIV	21 56 N	167 02	Do.	16.7	....	6 18 E	2	....	....	....	..	....	....	......	..	C1, D4	....	188	20	R	bc
292CIV	20 17 N	167 10	Sep 6	....	....	....	..	15.0	....	29 17 N	1	15.0	....	.3038	1	D4	189.1234†	101	40	R	or
293CIV	21 27 N	169 07	Sep 7	7.4	....	6 49 E	2	....	....	....	..	....	....	......	..	C1	....	112	43	R	bc
294CIV	21 30 N	169 19	Do.	....	....	....	..	14.5	....	31 08 N	1	14.4	....	.3004	1	D4	189.1234†	135	35	R	bcq
295CIV	21 31 N	169 22	Do.	16.6	....	6 58 E	2	....	....	....	..	....	....	......	..	C1, D4	....	135	40	R	bc
296CIV	21 21 N	169 47	Sep 8	6.3	....	7 20 E	2	....	....	....	..	....	....	......	..	C1, D4	....	107	15	R	bc
297CIV	21 15 N	169 19	Do.	....	....	....	..	14.8	....	30 38 N	2	14.8	....	.3025	2	D4	EI3,189.1234†	236	12	M	bc
298CIV	21 02 N	168 32	Sep 9	7.2	....	7 06 E	3	....	....	....	..	....	....	......	..	C1	....	208	11	S	bc
299CIV	21 01 N	168 30	Do.	....	....	....	..	14.5	....	30 24 N	2	14.5	....	.3028	2	D4	EI3,189.1234†	202	15	L	bc
300CIV	20 40 N	168 13	Sep 10	6.0	....	6 59 E	3	....	....	....	..	....	....	......	..	C1, D4	....	202	10	S	bc
301CIV	20 39 N	168 07	Do.	....	....	....	..	14.5	....	29 46 N	2	14.5	....	.3036	2	D4	EI3,189.1234†	214	15	SL	bc
302CIV	20 37 N	168 04	Do.	17.7	....	6 53 E	2	....	....	....	..	....	....	......	..	C1, D4	....	202	18	S	bc
303CIV	20 18 N	167 41	Sep 11	6.4	....	6 57 E	3	....	....	....	..	....	....	......	..	C1, D4	....	205	12	S	bc
304CIV	19 50 N	167 06	Do.	....	....	....	..	14.6	....	28 07 N	2	14.5	....	.3074	2	D4	EI3,189.1234†	236	7	SL	bc
305CIV	19 44 N	166 55	Do.	17.3	....	6 34 E	2	....	....	....	..	....	....	......	..	C1, D4	....	214	7	SL	bc
306CIV	19 14 N	166 28	Sep 12	6.3	....	6 57 E	3	....	....	....	..	....	....	......	..	C1, D4	....	191	9	S	bc
307CIV	18 45 N	166 11	Do.	....	....	....	..	14.6	....	26 09 N	3	14.6	....	.3121	3	D4	EI3,189.1234†	191	16	MS	bc
308CIV	18 36 N	166 06	Do.	17.4	....	6 37 E	3	....	....	....	..	....	....	......	..	C1, D4	....	191	12	S	bc
309CIV	17 32 N	165 33	Sep 13	6.3	....	6 34 E	3	....	....	....	..	....	....	......	..	C1, D4	....	180	9	S	bc
310CIV	16 43 N	165 21	Do.	....	....	....	..	14.6	....	22 32 N	3	14.6	....	.3170	2	D4	EI3,189.1234†	180	9	M	bc
311CIV	16 34 N	165 21	Do.	16.2	....	7 05 E	2	....	....	....	..	....	....	......	..	C1, D4	....	169	7	S	bc

FINAL RESULTS OF OCEAN MAGNETIC OBSERVATIONS ON THE CARNEGIE, 1915–1921—*Continued.*

CRUISE IV, PACIFIC OCEAN, 1915—*Continued.*

Station	Lat.	Long. East of Gr.	Date	Declination L. M. T.		Declination Value	Wt.	Inclination L. M. T.		Inclination Value	Wt.	Hor. intensity L. M. T.		Hor. intensity Value	Wt.	Instruments Compass	Instruments Dip Circle	Remarks Course	Roll	Sea	Weather
	° ′	° ′	*1915*	h	h	° ′		h	h	° ′		h	h	c. g. s.				°	°		
312CIV	5 29 N	165 17	Sep 14	6.1		6 41 E	3									C1, D4		169	6	S	bc
313CIV	15 06 N	165 12	Do.					14.8		20 20 N	2	14.7		0.3215	3	D4	EI3,189.1234†	236–174	11	MS	bc
314CIV	14 33 N	165 11	Do.	20.1		6 40 E	2									C1		174	11	S	bc
315CIV	14 13 N	164 50	Sep 15	6.7		6 52 E	3									C1, D4		146	6	S	bc
316CIV	14 17 N	164 55	Do.					15.0		18 50 N	2	14.9		.3228	2	D4	EI3,189.1234†	101	12	S	bc
317CIV	14 16 N	165 01	Do.	16.9		6 41 E	1									C1		101	10	S	bc
318CIV	14 00 N	165 33	Sep 16	6.1		6 55 E	3									C1, D4		98	10	M	bc
319CIV	13 48 N	166 11	Do.					14.4		18 24 N	2	14.4		.3232	2	D4	EI3,189.1234†	124	11	S	bc
320CIV	13 47 N	166 16	Do.	17.3		7 08 E	3									C1, D4		115	7	S	bc
321CIV	13 46 N	166 24	Sep 17	6.3		7 08 E	3									C1, D4		214	7	S	bc
322CIV	13 27 N	166 05	Do.					14.4		17 54 N	3	14.3		.3242	3	D4	EI3,189.1234†	214	10	S	bc
323CIV	13 21 N	165 58	Do.	16.3		7 02 E	3									C1, D4		191	8	S	bc
324CIV	12 29 N	165 01	Sep 18	6.2		7 08 E	3									C1, D4		208	6	S	bc
325CIV[1]	12 02 N	164 36	Do.					14.5		13 16 N	3	14.5		.3326	3	D4	EI3,189.1234†	186	7	S	bc
326CIV[1]	11 57 N	164 32	Do.	17.4		6 03 E	3									C1, D4		191	6	S	bc
327CIV	11 31 N	164 23	Sep 19	6.2		7 01 E	3									C1, D4		174	6	S	bc
328CIV	11 14 N	164 14	Do.					14.7		13 06 N	3	14.7		.3322	3	D4	EI3,189.1234†	174	6	S	b
329CIV	11 13 N	164 12	Do.	17.3		6 50 E	3									C1, D4		174	4	S	bc
330CIV	10 40 N	164 06	Sep 20	6.3		6 58 E	3									C1, D4		169	5	S	bc
331CIV	10 00 N	164 00	Do.					14.4		10 44 N	3	14.4		.3359	3	D4	EI3,189.1234†	174	4	S	bc
332CIV	9 46 N	163 56	Do.	17.5		6 47 E	3									C1, D4		180	4	S	b
333CIV	9 17 N	163 41	Sep 21	6.1		6 59 E	3									C1, D4		166	4	S	bc
334CIV	8 47 N	163 33	Do.					14.4		8 30 N	3	14.4		.3402	3	D4	EI3,189.1234†	180	10	S	bc
335CIV	8 40 N	163 29	Do.	17.1		6 50 E	3									C1, D4		197	9	S	bc
336CIV	8 06 N	163 32	Sep 22	6.7		7 04 E	3									C1, D4		135	6	S	bc
337CIV	8 04 N	163 39	Do.					14.6		7 11 N	3	14.6		.3414	2	D4	EI3,189.1234†	202	14	M	o
338CIV	7 45 N	163 47	Do.	21.8		6 45 E	2									C1		135	4	S	bc
339CIV	7 19 N	164 05	Sep 23	6.3		7 10 E	3									C1, D4		146	4	S	bc
340CIV	6 52 N	164 16	Do.					14.7		5 07 N	3	14.7		.3432	3	D4	189.1234†	135	8	S	bc
341CIV	6 42 N	164 20	Do.	17.7		7 10 E	3									C1, D4		146	8	S	bc
342CIV	5 56 N	164 38	Sep 24	6.4		7 33 E	3									C1, D4		141	8	S	bc
343CIV	5 09 N	164 38	Do.					14.5		1 42 N	3	14.5		.3479	2	D4	EI3,189.1234†	186	10	M	bc
344CIV	4 56 N	164 33	Do.	17.5		7 32 E	3									C1, D4		191	8	S	bc
345CIV	4 23 N	164 14	Sep 25	6.6		7 26 E	3									C1, D4		236	10	S	bc
346CIV	4 17 N	163 58	Do.					13.7		0 07 S	3	13.8		.3506	3	D4	189.1234†	225	8	S	b
347CIV	4 16 N	163 54	Do.	16.7		7 14 E	3									C1, D4		214	6	S	bc
348CIV	4 04 N	163 50	Sep 26	6.4		7 20 E	3									C1, D4		135	9	S	bc
349CIV	3 52 N	163 58	Do.					14.9		0 44 S	3	14.8		.3507	3	D4	EI3,189.1234†	141–101	9	M	bc
350CIV	3 40 N	163 56	Sep 27	6.7		7 16 E	3									C1, D4		180	9	S	bc
351CIV	3 40 N	163 50	Do.					14.7		1 02 S	3	14.7		.3530	2	D4	EI3,189.1234†	186	9	S	bq
352CIV	3 36 N	163 45	Do.	16.7		7 19 E	2									C1, D4		214	5	S	bc
353CIV	3 25 N	163 02	Sep 28	6.3		7 19 E	2									C1, D4		68	5	S	bc
354CIV	3 16 N	162 51	Do.					14.6		2 22 S	2	14.5		.3540	2	D4	EI3,189.1234†	214	7	M	bc
355CIV	3 11 N	162 42	Do.	17.0		7 11 E	3									C1, D4		214	5	S	bc
356CIV	3 01 N	162 05	Sep 29	6.2		7 09 E	2									C1, D4		68	6	S	bc
357CIV	2 59 N	162 06	Do.					14.2		3 14 S	3	14.2		.3543	3	D4	EI3,189.1234†	174	6	S	bc
358CIV	2 56 N	162 05	Do.	16.2		7 09 E	2									C1, D4		166	5	S	bc
359CIV	2 28 N	161 53	Sep 30	6.2		7 05 E	3									C1, D4		202	5	S	bq

[1] Local disturbance near Marshall Islands.

CRUISE IV, PACIFIC OCEAN, 1915—*Continued.*

	° ′	° ′	*1915*	h	h	° ′		h	h	° ′		h	h	c. g. s.				°	°		
360CIV	2 20 N	161 36	Sep 30	....	....	....	..	14.4	....	4 50 S	3	14.4	....	0.3570	3	D4	EI3,189.1234†	166	5	S	bo
361CIV	2 20 N	161 32	Do.	17.2	....	6 55 E	3	....	....	....	..	....	....	......	..	C1, D4	....	158	4	S	bo
362CIV	1 55 N	160 34	Oct 1	6.3	....	6 53 E	3	....	....	....	..	....	....	......	..	C1, D4	....	197	6	S	bo
363CIV	2 00 N	160 41	Do.	....	....	....	..	13.6	....	5 44 S	2	13.6	....	.3576	2	D4	EI3,189.1234†	73	7	S	bo
364CIV	2 05 N	160 50	Do.	17.4	....	6 49 E	3	....	....	....	..	....	....	......	..	C1, D4	....	186	6	S	bo
365CIV	1 01 N	160 07	Oct 2	6.1	....	6 49 E	3	....	....	....	..	....	....	......	..	C1, D4	....	186	3	S	bo
366CIV	0 10 N	159 51	Do.	....	....	....	..	14.3	....	9 30 S	3	14.3	....	.3619	2	D4	EI3,189.1234†	162	3	S	bo
367CIV	0 04 S	159 50	Do.	16.8	....	6 45 E	3	....	....	....	..	....	....	......	..	C1, D4	....	160	3	S	bo
368CIV	1 31 S	159 43	Oct 3	6.3	....	6 52 E	3	....	....	....	..	....	....	......	..	C1, D4	....	146	3	S	bo
369CIV	2 25 S	160 03	Do.	....	....	....	..	14.6	....	14 40 S	3	14.6	....	.3648	2	D4	EI3,189.1234†	135	7	M	bo
370CIV	2 40 S	160 11	Do.	16.8	....	7 18 E	2	....	....	....	..	....	....	......	..	C1	....	124	4	M	bo
371CIV	3 46 S	160 54	Oct 4	6.1	....	7 24 E	2	....	....	....	..	....	....	......	..	C1, D4	....	124	16	M	bo
372CIV	4 24 S	161 16	Do.	....	....	....	..	14.6	....	18 02 S	2	14.6	....	.3663	2	D4	EI3,189.1234†	124	13	M	bo
373CIV	4 29 S	161 21	Do.	16.3	....	7 25 E	2	....	....	....	..	....	....	......	..	C1, D4	....	112	13	M	bo
374CIV	4 58 S	161 48	Oct 5	6.5	....	7 33 E	2	....	....	....	..	....	....	......	..	C1, D4	....	101	9	M	br
375CIV	5 12 S	162 20	Do.	....	....	....	..	13.8	....	19 31 S	2	13.8	....	.3671	2	D4	189.1234†	122	10	M	o
376CIV	5 49 S	163 29	Oct 6	....	....	....	..	13.8	....	20 20 S	3	13.8	....	.3673	2	D4	189.1234†	128	6	MS	bo
377CIV	5 56 S	163 36	Do.	16.3	....	8 10 E	2	....	....	....	..	....	....	......	..	C1	....	158	6	S	o
378CIV	6 30 S	164 02	Oct 7	....	....	....	..	14.9	....	21 12 S	3	14.8	....	.3669	2	D4	EI3,189.1234†	146	12	M	or
379CIV	6 31 S	164 03	Do.	16.5	....	8 00 E	2	....	....	....	..	....	....	......	..	C1, D4	....	158	6	S	o
380CIV	7 20 S	163 25	Oct 8	7.1	....	7 59 E	2	....	....	....	..	....	....	......	..	C1, D4	....	191	6	S	bo
381CIV	7 55 S	163 12	Do.	....	....	....	..	14.2	....	24 40 S	3	14.2	....	.3675	2	D4	EI3,189.1234†	171	8	M	bo
382CIV	8 08 S	163 09	Do.	17.1	....	8 14 E	3	....	....	....	..	....	....	......	..	C1, D4	....	169	3	S	bo
383CIV	9 09 S	162 50	Oct 9	6.4	....	8 31 E	3	....	....	....	..	....	....	......	..	C1, D4	....	174	8	M	bo
384CIV	9 36 S	162 42	Do.	....	....	....	..	14.6	....	27 28 S	3	14.6	....	.3658	3	D4	189.1234†	174	8	S	bo
385CIV	9 44 S	162 36	Do.	17.0	....	8 04 E	3	....	....	....	..	....	....	......	..	C1, D4	....	191	8	S	bo
386CIV	10 24 S	162 44	Oct 10	....	....	....	..	13.6	....	28 56 S	3	13.6	....	.3649	2	D4	189.1234†	88	6	M	br
387CIV	11 20 S	162 31	Oct 11	6.2	....	8 17 E	3	....	....	....	..	....	....	......	..	C1, D4	....	180	10	S	bo
388CIV	11 56 S	161 48	Do.	....	....	....	..	14.0	....	32 08 S	3	14.1	....	.3621	2	D4	189.1234†	214	7	M	bo
389CIV	12 12 S	161 28	Do.	17.2	....	8 11 E	3	....	....	....	..	....	....	......	..	C1, D4	....	214	7	S	bo
390CIV	12 24 S	161 22	Oct 12	6.1	....	8 08 E	2	....	....	....	..	....	....	......	..	C1, D4	....	214	11	M	bo
391CIV	12 54 S	160 45	Do.	....	....	....	..	13.8	....	33 55 S	2	13.8	....	.3602	2	D4	189.1234†	68	15	R	bo
392CIV	13 01 S	160 42	Do.	16.9	....	8 11 E	2	....	....	....	..	....	....	......	..	C1, D4	....	208	7	M	bo
393CIV	13 52 S	159 58	Oct 13	6.0	....	8 08 E	2	....	....	....	..	....	....	......	..	C1, D4	....	202	7	M	bo
394CIV	14 02 S	159 34	Do.	....	....	....	..	14.4	....	36 11 S	3	14.4	....	.3579	3	D4	EI3,189.1234†	236	11	S	bo
395CIV	14 14 S	159 19	Do.	17.4	....	7 58 E	3	....	....	....	..	....	....	......	..	C1, D4	....	214	4	S	bo
396CIV	15 33 S	158 41	Oct 14	6.1	....	7 54 E	3	....	....	....	..	....	....	......	..	C1, D4	....	180	7	M	bo
397CIV	16 41 S	158 16	Do.	....	....	....	..	14.2	....	40 44 S	3	14.1	....	.3513	2	D4	EI3,189.1234†	184	7	M	bo
398CIV	17 02 S	158 08	Do.	17.0	....	8 04 E	3	....	....	....	..	....	....	......	..	C1, D4	....	186	6	M	bo
399CIV	18 37 S	157 46	Oct 15	5.9	....	8 23 E	3	....	....	....	..	....	....	......	..	C1, D4	....	174	14	M	bo
400CIV[1]	19 52 S	157 31	Do.	....	....	....	..	14.4	....	45 17 S	3	14.4	....	.3409	2	D4	EI3,189.1234†	180	9	M	bo
401CIV	20 16 S	157 24	Do.	17.3	....	8 20 E	3	....	....	....	..	....	....	......	..	C1, D4	....	180	5	M	bo
402CIV	21 34 S	157 22	Oct 16	5.8	....	8 59 E	3	....	....	....	..	....	....	......	..	C1, D4	....	169	5	S	b
403CIV	21 44 S	157 12	Do.	....	....	....	..	14.6	....	48 37 S	3	14.5	....	.3282	3	D4	EI3,189.1234†	230	6	S	bo
404CIV	21 50 S	157 05	Do.	17.3	....	8 55 E	3	....	....	....	..	....	....	......	..	C1, D4	....	214	4	S	b
405CIV	22 07 S	156 51	Oct 17	5.8	....	8 58 E	3	....	....	....	..	....	....	......	..	C1, D4	....	169	6	S	b
406CIV	22 20 S	156 52	Do.	....	....	....	..	14.6	....	49 18 S	3	14.6	....	.3262	3	D4	EI3,189.1234†	Beclm'd	7	S	om
407CIV	23 10 S	157 00	Oct 18	5.8	....	8 40 E	3	....	....	....	..	....	....	......	..	C1, D4	....	169	5	M	bo
408CIV	23 40 S	157 00	Do.	....	....	....	..	14.2	....	51 04 S	3	14.2	....	.3209	3	D4	EI3,189.1234†	169	7	M	b
409CIV	23 43 S	157 00	Do.	17.2	....	8 50 E	3	....	....	....	..	....	....	......	..	C1, D4	....	169	9	S	bo
410CIV	23 55 S	156 50	Oct 19	5.8	....	8 58 E	3	....	....	....	..	....	....	......	..	C1, D4	....	180	5	S	bo
411CIV	24 36 S	156 13	Do.	....	....	....	..	15.6	....	52 26 S	2	14.6	....	.3156	2	D4	EI3,189.1234†	197	7	M	o
412CIV	25 43 S	155 33	Oct 20	5.9	....	9 02 E	2	....	....	....	..	....	....	......	..	C1, D4	....	186	5	M	bo
413CIV	26 23 S	155 05	Do.	....	....	....	..	14.6	....	54 45 S	2	14.6	....	.3069	2	D4	EI3,189.1234†	197	8	M	b
414CIV	26 38 S	154 57	Do.	17.3	....	8 43 E	2	....	....	....	..	....	....	......	..	C1, D4	....	197	10	M	bo
415CIV	27 34 S	154 32	Oct 21	5.8	....	9 33 E	2	....	....	....	..	....	....	......	..	C1, D4	....	186	9	M	bo
416CIV	28 17 S	154 26	Do.	....	....	....	..	14.6	....	57 13 S	3	14.3	....	.2942	2	D4	EI3,189.1234†	191–174	7	M	b
417CIV	28 35 S	154 30	Do.	17.5	....	9 23 E	3	....	....	....	..	....	....	......	..	C1, D4	....	158	5	M	bo

[1] Local disturbance near Chesterfield reefs.

FINAL RESULTS OF OCEAN MAGNETIC OBSERVATIONS ON THE CARNEGIE, 1915–1921—*Continued.*

CRUISE IV, PACIFIC OCEAN, 1915—*Concluded.*

Station	Lat.	Long. East of Gr.	Date	Declination L. M. T.		Declination Value	Wt.	Inclination L. M. T.		Inclination Value	Wt.	Hor. intensity L. M. T.		Hor. intensity Value	Wt.	Instruments Compass	Instruments Dip Circle	Remarks Course	Remarks Roll	Remarks Sea	Weather
	° ′	° ′	*1915*	*h*	*h*	° ′		*h*	*h*	° ′		*h*	*h*	*c. g. s.*				°	°		
418CIV	29 43 S	155 12	Oct 22	6.0	....	9 31 E	3	....	....	....	..	....	....	......	..	C1, D4	....	124	5	M	bo
419CIV	30 29 S	155 41	Do.	....	....	....	..	14.6	....	59 19 S	3	14.6	....	0.2846	3	D4	EI3,189.1234†	135	5	M	b
420CIV	30 48 S	155 54	Do.	17.4	....	9 58 E	3	....	....	....	..	....	....	......	..	C1, D4	....	135	6	M	bo
421CIV	32 19 S	156 59	Oct 23	16.5	....	10 32 E	3	....	....	....	..	....	....	......	..	C1, D4	....	151	14	M	bo
422CIV	33 30 S	157 25	Do.	....	....	....	..	14.4	....	61 59 S	3	14.4	....	.2668	2	D4	EI3,189.1234†	151	15	M	bo
423CIV	33 48 S	157 34	Do.	16.7	....	11 04 E	3	....	....	....	..	....	....	......	..	C1, D4	....	151	10	M	bo
424CIV	35 32 S	158 14	Oct 24	9.4	....	11 28 E	2	....	....	....	..	....	....	......	..	C1	....	151	13	ML	o
425CIV	35 45 S	158 28	Do.	....	....	....	..	14.8	....	64 13 S	2	14.7	....	.2547	2	D4	EI3,189.1234†	112	12	M	bo
426CIV	35 54 S	158 48	Do.	16.8	....	11 41 E	2	....	....	....	..	....	....	......	..	C1, D4	....	112	12	M	bo
427CIV	36 22 S	159 51	Oct 25	7.1	....	12 55 E	3	....	....	....	..	....	....	......	..	C1, D4	....	219	6	M	bo
428CIV	36 19 S	159 50	Do.	....	....	....	..	14.6	....	64 15 S	2	14.6	....	.2532	2	D4	EI3,189.1234†	Var.191	20	ML	o
429CIV	37 00 S	160 40	Oct 26	6.2	....	13 01 E	3	....	....	....	..	....	....	......	..	C1, D4	....	68	6	M	bo
430CIV	37 20 S	161 23	Do.	....	....	....	..	14.4	....	64 52 S	2	14.4	....	.2477	2	D4	EI3,189.1234†	150	12	M	bo
431CIV	37 27 S	161 27	Do.	16.2	....	13 01 E	2	....	....	....	..	....	....	......	..	C1, D4	....	146	8	M	bo
432CIV	38 12 S	161 47	Oct 27	5.4	....	13 14 E	3	....	....	....	..	....	....	......	..	C1, D4	....	143	8	M	bo
433CIV	38 35 S	161 51	Do.	....	....	....	..	14.3	....	65 58 S	3	14.3	....	.2412	2	D4	EI3,189.1234†	163	9	S	bo
434CIV	38 41 S	161 52	Do.	15.8	....	13 14 E	2	....	....	....	..	....	....	......	..	C1, D4	....	163	7	S	bo
435CIV	39 14 S	161 57	Oct 28	7.8	....	13 28 E	2	....	....	....	..	....	....	......	..	C1, D4	....	163	8	ML	bo
436CIV	39 21 S	162 04	Do.	....	....	....	..	14.4	....	66 29 S	3	14.1	....	.2377	2	D4	EI3,189.1234†	142	8	S	bo
437CIV	39 35 S	162 10	Do.	17.1	....	14 01 E	3	....	....	....	..	....	....	......	..	C1, D4	....	160	7	M	bo
438CIV	41 57 S	162 26	Oct 29	5.3	....	14 40 E	3	....	....	....	..	....	....	......	..	C1, D4	....	174	14	ML	bo
439CIV	42 10 S	162 38	Do.	....	....	....	..	14.5	....	68 43 S	2	14.5	....	.2213	2	D4	EI3,189.1234†	162	20	M	or
440CIV [1]	42 31 S	162 42	Do.	17.4	....	14 59 E	2	....	....	....	..	....	....	......	..	C1, D4	....	146	11	ML	bo
441CIV	43 58 S	163 29	Oct 30	5.5	....	15 37 E	1	....	....	....	..	....	....	......	..	C1, D4	....	146	15	R	bo
442CIV	45 13 S	164 30	Do.	....	....	....	..	14.5	....	70 41 S	2	14.5	....	.2047	2	D4	EI3,189.1234†	135	22	R	bo
443CIV [1]	45 36 S	164 53	Do.	17.4	....	16 22 E	1	....	....	....	..	....	....	......	..	C1, D4	....	135	25	R	bqr
444CIV	46 31 S	167 20	Oct 31	8.3	....	16 49 E	1	....	....	....	..	....	....	......	..	C1	....	112	11	M	bqr
445CIV [2]	46 41 S	168 13	Do.	....	....	....	..	14.4	....	71 19 S	2	14.4	....	.2002	2	D4	EI3,189.1234†	93–107	8	S	o
446CIV	46 10 S	170 26	Nov 1	....	....	....	..	14.2	....	70 25 S	3	14.1	....	.2065	2	D4	EI3,189.1234†	45	9	MS	o
447CIV	45 14 S	172 00	Nov 2	4.8	....	17 37 E	3	....	....	....	..	....	....	......	..	C1, D4	....	17	9	S	bo
448CIV	44 27 S	172 44	Do.	....	....	....	..	14.5	....	68 41 S	2	14.5	....	.2192	3	D4	EI3,189.1234†	6	8	S	bo
449CIV	44 16 S	172 50	Do.	17.6	....	17 14 E	3	....	....	....	..	....	....	......	..	C1, D4	....	6	6	S	bo
450CIV [3]	43 42 S	173 09	Nov 3	4.8	....	16 58 E	3	....	....	....	..	....	....	......	..	C1, D4	....	338	6	M	bo

CRUISE IV, SOUTHERN OCEAN, 1915–1916.

Station	Lat.	Long. East of Gr.	Date	Declination L. M. T.		Declination Value	Wt.	Inclination L. M. T.		Inclination Value	Wt.	Hor. intensity L. M. T.		Hor. intensity Value	Wt.	Instruments Compass	Instruments Dip Circle	Remarks Course	Remarks Roll	Remarks Sea	Weather
	° ′	° ′	*1915*	*h*	*h*	° ′		*h*	*h*	° ′		*h*	*h*	*c. g. s.*				°	°		
451CIV	43 47 S	173 20	Dec 6	16.3	....	17 07 E	2	....	....	....	..	....	....	......	..	C1, D4	....	124	8	MC	bo
452CIV	46 04 S	174 39	Dec 7	8.8	....	17 50 E	1	....	....	....	..	....	....	......	..	C1	....	141	16	ML	o
453CIV	46 27 S	174 51	Do.	....	....	....	..	15.0	....	69 55 S	2	15.0	....	0.2095	2	D4	EI3,189.1234†	141	21	M	o
454CIV	47 37 S	176 16	Dec 8	9.9	....	18 16 E	1	....	....	....	..	....	....	......	..	C1	....	163	16	M	o
455CIV	48 10 S	176 39	Do.	....	....	....	..	15.0	....	70 29 S	1	15.0	....	.2061	1	D4	189.1234†	141	19	R	od
456CIV	49 03 S	178 21	Dec 9	8.4	....	18 24 E	1	....	....	....	..	....	....	......	..	C1	....	112	18	R	bo
457CIV	49 18 S	179 01	Do.	....	....	....	..	14.8	....	71 08 S	2	14.8	....	.1993	2	D4	EI3,189.1233†	112	16	R	bo
458CIV	49 23 S	179 13	Do.	16.7	....	20 23 E	2	....	....	....	..	....	....	......	..	C1, D4	....	112	16	R	o
459CIV [4]	49 56 S	180 47	Do.	5.5	....	20 22 E	3	....	....	....	..	....	....	......	..	C1, D4	....	79,73	30	R	bo

[1] Mean of 2 stations. [2] Local disturbance, passing through Foveaux Strait. [3] From November 3 to December 6 the *Carnegie* was at Lyttelton. [4] Date repeated on crossing the 180th meridian.

CRUISE IV, SOUTHERN OCEAN, 1915–1916—*Continued.*

	° ′	° ′	*1915*	h	h	° ′		h	h	° ′		h	h	c.g.s.				°	°		
460CIV	50 20 S	182 09	Dec 9	....	....	....	..	14.7	....	71 17 S	2	14.8	....	0.1988	2	D4	EI3,189.1234†	107	17	R	bo
461CIV	50 28 S	182 26	Do.	16.8	....	21 30 E	2	....	....	....	..	....	....	......	..	C1, D4	....	112	30	R	ob
462CIV	50 34 S	182 44	Do.	18.9	....	20 54 E	2	....	....	....	..	....	....	......	..	C1, D4	....	112	30	R	bo
463CIV	51 27 S	184 11	Dec 10	....	....	....	..	14.8	....	72 02 S	2	14.8	....	.1916	2	D4	EI3,189.1234†	135	7	R	od
464CIV	51 29 S	184 13	Do.	15.0	....	21 16 E	1	....	....	....	..	....	....	......	..	C1	....	135	10	MR	od
465CIV	53 03 S	186 18	Dec 11	7.0	....	22 23 E	2	....	....	....	..	....	....	......	..	C1, D4	....	34	24	R	bo
466CIV	53 28 S	187 10	Do.	....	....	....	..	14.5	....	72 53 S	2	14.5	....	.1841	2	D4	EI3,189.1234†	135	8	ML	bo
467CIV	53 34 S	187 17	Do.	16.2	....	21 33 E	2	....	....	....	..	....	....	......	..	C1	....	135	16	M	oo
468CIV	53 51 S	187 44	Do.	21.6	....	21 58 E	2	....	....	....	..	....	....	......	..	C1	....	112	10	M	bo
469CIV	54 18 S	188 18	Dec 12	8.2	....	22 01 E	2	....	....	....	..	....	....	......	..	C1	....	22	12	M	d
470CIV	53 45 S	189 24	Do.	....	....	....	..	15.0	....	72 55 S	1	15.0	....	.1855	2	D4	EI3,189.1234†	66	14	R	bo
471CIV	53 44 S	189 47	Do.	17.4	....	22 22 E	3	....	....	....	..	....	....	......	..	C1, D4	....	90	13	R	bo
472CIV	54 12 S	191 11	Dec 13	6.0	....	22 37 E	3	....	....	....	..	....	....	......	..	C1, D4	....	68	16	M	bo
473CIV	54 38 S	192 01	Do.	....	....	....	..	14.9	....	72 59 S	2	14.8	....	.1857	2	D4	EI3,189.1234†	117	13	ML	bo
474CIV	54 46 S	192 15	Do.	17.5	....	23 19 E	3	....	....	....	..	....	....	......	..	C1, D4	....	124	10	M	bo
475CIV	55 12 S	193 35	Dec 14	5.6	....	22 55 E	3	....	....	....	..	....	....	......	..	C1, D4	....	68	12	MR	bo
476CIV	55 28 S	195 36	Do.	....	....	....	..	16.3	....	73 05 S	1	16.3	....	.1848	1	D4	EI3,189.1234†	92	19	R	o
477CIV	55 29 S	195 38	Do.	16.3	....	23 34 E	1	....	....	....	..	....	....	......	..	C1	....	90	21	R	bq
478CIV	55 43 S	196 34	Do.	22.1	....	22 58 E	1	....	....	....	..	....	....	......	..	C1	....	112	14	ML	bo
479CIV	56 00 S	197 27	Dec 15	5.9	....	24 20 E	3	....	....	....	..	....	....	......	..	C1, D4	....	56	10	M	bo
480CIV	56 05 S	198 08	Do.	....	....	....	..	14.8	....	73 07 S	2	14.8	....	.1834	2	D4	EI3,189.1234†	77	10	M	o
481CIV	56 08 S	198 25	Do.	16.7	....	23 58 E	2	....	....	....	..	....	....	......	..	C1	....	79	12	M	or
482CIV	57 21 S	202 21	Dec 16	....	....	....	..	14.6	....	73 31 S	2	14.6	....	.1794	2	D4	EI3,189.1234†	112	19	R	bo
483CIV	57 36 S	202 45	Do.	17.9	....	25 41 E	2	....	....	....	..	....	....	......	..	C1	....	112	20	ML	o
484CIV	58 25 S	204 21	Dec 17	6.1	....	26 50 E	2	....	....	....	..	....	....	......	..	C1, D4	....	135	20	ML	o
485CIV	59 15 S	205 57	Do.	....	....	....	..	14.9	....	74 26 S	2	14.8	....	.1717	2	D4	EI3,189.1234†	112	23	MR	o
486CIV	59 26 S	206 18	Do.	16.9	....	27 02 E	1	....	....	....	..	....	....	......	..	C1	....	112	22	ML	o
487CIV	60 16 S	208 42	Dec 18	8.6	....	29 26 E	1	....	....	....	..	....	....	......	..	C1	....	101	12	M	o
488CIV	60 10 S	209 28	Do.	....	....	....	..	15.1	....	74 47 S	2	15.1	....	.1694	2	D4	EI3,189.1234†	51	11	R	o
489CIV	60 18 S	212 42	Dec 19	5.2	....	29 17 E	2	....	....	....	..	....	....	......	..	C1	....	62	30	M	s
490CIV	60 20 S	214 56	Do.	....	....	....	..	14.4	....	73 59 S	2	14.4	....	.1761	2	D4	EI3,189.1234†	68	18	M	ms
491CIV	60 20 S	215 30	Do.	16.7	....	30 44 E	1	....	....	....	..	....	....	......	..	C1	....	56	20	M	s
492CIV	60 26 S	218 49	Dec 20	5.4	....	30 36 E	2	....	....	....	..	....	....	......	..	C1	....	22	15	ML	s
493CIV	60 32 S	221 04	Do.	....	....	....	..	15.2	....	73 05 S	2	15.2	....	.1827	3	D4	EI3,189.1234†	56	13	ML	o
494CIV	60 32 S	221 08	Do.	15.4	....	30 56 E	1	....	....	....	..	....	....	......	..	C1	....	56	14	M	s
495CIV	60 10 S	227 27	Dec 21	....	....	....	..	15.1	....	72 06 S	1	15.1	....	.1919	1	D4	189.1234†	45	16	R	s
496CIV	60 09 S	227 32	Do.	15.3	....	30 26 E	1	....	....	....	..	....	....	......	..	C1	....	34	28	M	s
497CIV	59 46 S	230 32	Dec 22	3.4	....	30 52 E	1	....	....	....	..	....	....	......	..	C1	....	34	30	M	o
498CIV	59 40 S	231 11	Do.	7.5	....	30 46 E	1	....	....	....	..	....	....	......	..	C1	....	22	30	M	o
499CIV	59 39 S	232 30	Do.	....	....	....	..	15.2	....	70 58 S	2	15.1	....	.2011	2	D4	EI3,189.1234†	50	17	ML	bo
500CIV	59 38 S	232 44	Do.	17.3	....	31 59 E	3	....	....	....	..	....	....	......	..	C1, D4	....	45	7	M	bo
501CIV	60 32 S	235 56	Dec 23	10.0	....	32 43 E	1	....	....	....	..	....	....	......	..	C1	....	79	16	M	o
502CIV	60 33 S	236 14	Do.	....	....	....	..	14.9	....	70 30 S	1	14.9	....	.2031	2	D4	EI3,189.1234†	288	12	M	o
503CIV	60 06 S	235 39	Dec 24	8.3	....	32 19 E	1	....	....	....	..	....	....	......	..	C1	....	Var.304	9	M	f
504CIV	59 41 S	236 28	Do.	....	....	....	..	15.3	....	69 59 S	2	15.3	....	.2093	2	D4	EI3,189.1234†	355	17	R	o
505CIV	59 37 S	236 34	Do.	15.7	....	31 40 E	1	....	....	....	..	....	....	......	..	C1	....	0	15	M	o
506CIV	59 14 S	241 34	Dec 25	9.9	....	31 41 E	1	....	....	....	..	....	....	......	..	C1	....	79	15	M	o
507CIV	59 10 S	242 58	Do.	....	....	....	..	14.1	....	68 9 S	2	14.1	....	.2196	2	D4	189.1234†	56	25	RL	o
508CIV	59 10 S	244 09	Do.	17.7	....	31 43 E	1	....	....	....	..	....	....	......	..	D4	....	45	27	R	o
509CIV	59 08 S	247 40	Dec 26	5.6	....	31 25 E	2	....	....	....	..	....	....	......	..	C1	....	28	17	M	d
510CIV	59 06 S	250 16	Do.	15.5	....	31 20 E	1	15.6	....	66 29 S	2	15.6	....	.2338	2	C1, D4	EI3,189.1234†	56	23	R	od
511CIV	59 05 S	251 16	Do.	18.9	....	31 38 E	2	....	....	....	..	....	....	......	..	C1, D4	....	45	20	ML	bo
512CIV	59 07 S	254 23	Dec 27	4.7	....	31 51 E	2	....	....	....	..	....	....	......	..	C1, D4	....	22	15	L	o
513CIV	59 09 S	257 18	Do.	....	....	....	..	14.7	....	64 33 S	2	14.6	....	.2408	2	D4	EI3,189.1234†	51	25	R	oq
514CIV	59 07 S	257 36	Do.	15.6	....	31 02 E	1	....	....	....	..	....	....	......	..	C1	....	11	22	L	bq
515CIV	59 03 S	258 34	Do.	18.8	....	30 42 E	2	....	....	....	..	....	....	......	..	C1, D4	....	34	26	L	bq
516CIV	58 54 S	261 00	Dec 28	4.1	....	30 57 E	2	....	....	....	..	....	....	......	..	C1	....	51	19	MR	o
517CIV	58 47 S	263 39	Do.	....	....	....	..	14.9	....	62 22 S	2	14.9	....	.2505	2	D4	EI3,189.1234†	62	18	R	bo
518CIV	58 48 S	264 06	Do.	16.7	....	30 29 E	2	....	....	....	..	....	....	......	..	C1, D4	....	79	16	MR	bo

FINAL RESULTS OF OCEAN MAGNETIC OBSERVATIONS ON THE CARNEGIE, 1915–1921—*Continued.*

CRUISE IV, SOUTHERN OCEAN, 1915–1916—*Continued.*

Station	Lat.	Long. East of Gr.	Date	Declination L. M. T.		Declination Value	Declination Wt.	Inclination L. M. T.		Inclination Value	Inclination Wt.	Hor. intensity L. M. T.		Hor. intensity Value	Hor. intensity Wt.	Instruments Compass	Instruments Dip Circle	Remarks Course	Remarks Roll	Remarks Sea	Weather
	° ′	° ′	1915	h	h	° ′		h	h	° ′		h	h	c. g. s.				°	°		
519CIV	58 48 S	265 02	Dec 28	20.0	....	30 07 E	2	....	....	....	..	....	....	......	..	C1, D4	....	62	22	MR	or
520CIV	58 48 S	267 33	Dec 29	6.9	....	29 07 E	2	....	....	....	..	....	....	......	..	C1, D4	....	0	10	MR	o
521CIV	58 48 S	268 57	Do.	....	....	....	..	14.5	....	60 38 S	2	14.5	....	0.2578	2	D4	E13,189.1234†	62	11	M	bc
522CIV	58 48 S	269 30	Do.	17.8	....	28 50 E	3	....	....	....	..	....	....	......	..	C1, D4	....	79	25	ML	bc
523CIV	58 48 S	270 14	Dec 30	3.8	....	28 35 E	3	....	....	....	..	....	....	......	..	C1, D4	....	51	24	M	bc
524CIV	58 49 S	271 53	Do.	....	....	....	..	14.8	....	59 40 S	3	14.7	....	.2589	3	D4	E13,189.1234†	56	15	ML	bc
525CIV	58 49 S	272 08	Do.	18.0	....	27 46 E	3	....	....	....	..	....	....	......	..	C1, D4	....	68	14	M	bc
526CIV	58 50 S	273 02	Dec 31	3.8	....	27 55 E	3	....	....	....	..	....	....	......	..	C1, D4	....	56	12	M	bc
527CIV	59 02 S	274 54	Do.	....	....	....	..	14.4	....	59 04 S	3	14.4	....	.2608	3	D4	E13,189.1234†	73	9	M	o
528CIV	59 08 S	275 38	Do.	18.0	....	26 47 E	3	....	....	....	..	....	....	......	..	C1, D4	....	68	9	M	b
			1916																		
529CIV	59 12 S	277 39	Jan 1	3.2	....	25 47 E	3	....	....	....	..	....	....	......	..	C1, D4	....	68	8	M	b
530CIV	59 22 S	280 39	Do.	14.2	....	24 43 E	1	....	....	....	..	....	....	......	..	C1	....	79	9	M	o
531CIV	59 25 S	280 52	Do.	....	....	....	..	15.0	....	58 08 S	2	15.0	....	.2609	2	D4	E13,189.1234†	80	9	M	bc
532CIV	59 58 S	284 31	Jan 2	8.2	....	22 41 E	1	....	....	....	..	....	....	......	..	C1	....	68	10	M	f
533CIV	60 08 S	286 12	Do.	....	....	....	..	14.6	....	57 07 S	2	14.6	....	.2632	2	D4	E13,189.1234†	68	14	M	f
534CIV	60 08 S	286 20	Do.	15.0	....	22 26 E	1	....	....	....	..	....	....	......	..	C1	....	56	10	M	fd
535CIV	59 56 S	289 41	Jan 3	5.1	....	20 23 E	3	....	....	....	..	....	....	......	..	C1, D4	....	45	20	M	bc
536CIV	59 41 S	291 40	Do.	14.8	....	18 46 E	2	14.8	....	55 32 S	3	14.8	....	.2648	3	C1, D4	E13,189.1234†	68	12	M	bc
537CIV	59 41 S	292 39	Do.	19.2	....	19 04 E	3	....	....	....	..	....	....	......	..	C1, D4	....	68	17	M	bc
538CIV	59 53 S	294 04	Jan 4	4.7	....	17 48 E	2	....	....	....	..	....	....	......	..	C1	....	112	6	S	f
539CIV	60 00 S	294 41	Do.	....	....	....	..	14.3	....	55 11 S	3	14.3	....	.2635	3	D4	E13,189.1234†	331	5	M	f
540CIV	59 33 S	295 58	Jan 5	5.0	....	16 27 E	3	....	....	....	..	....	....	......	..	C1, D4	....	56	18	M	bc
541CIV	59 12 S	297 53	Do.	14.8	....	15 06 E	1	14.8	....	53 52 S	3	14.8	....	.2634	3	C1, D4	E13,189.1234†	56	12	M	bc
542CIV	59 04 S	298 50	Do.	19.4	....	14 13 E	3	....	....	....	..	....	....	......	..	C1, D4	....	39	7	M	b
543CIV	58 47 S	300 41	Jan 6	3.5	....	13 44 E	3	....	....	....	..	....	....	......	..	C1, D4	....	56	12	M	b
544CIV	58 41 S	303 09	Do.	....	....	....	..	14.5	....	52 50 S	2	14.5	....	.2623	2	D4	E13,189.1234†	68	12	R	o
545CIV	58 00 S	306 53	Jan 7	8.3	....	8 44 E	1	....	....	....	..	....	....	......	..	C1	....	332	19	R	bc
546CIV	57 35 S	308 17	Do.	....	....	....	..	15.0	....	51 22 S	2	14.9	....	.2578	2	D4	E13,189.1234†	57	17	M	bc
547CIV	57 26 S	308 58	Do.	17.5	....	7 28 E	2	....	....	....	..	....	....	......	..	C1	....	56	20	RL	o
548CIV	56 21 S	313 04	Jan 8	....	....	....	..	14.8	....	49 57 S	3	14.8	....	.2537	3	D4	E13,189.1234†	56	21	M	d
549CIV	56 20 S	313 06	Do.	14.8,	17.8	3 53 E	2	....	....	....	..	....	....	......	..	C1, D4	....	56	18	S	bc
550CIV	55 35 S	315 17	Jan 9	8.4	....	2 19 E	1	....	....	....	..	....	....	......	..	C1	....	34	12	M	o
551CIV	55 28 S	315 41	Do.	....	....	....	..	14.1	....	49 29 S	3	14.1	....	.2511	3	D4	189.1234†	56	12	M	bc
552CIV	54 18 S	319 17	Jan 10	14.3	....	1 22 W	1	....	....	....	..	....	....	......	..	C1	....	56	6	S	o
553CIV	54 16 S	319 23	Do.	....	....	....	..	14.8	....	48 34 S	3	14.8	....	.2474	3	D4	E13,189.1234†	62	6	M	o
554CIV	54 09 S	321 37	Jan 11	8.4	....	3 26 W	1	....	....	....	..	....	....	......	..	C1	....	236	8	M	f
555CIV	53 57 S	321 28	Do.	....	....	....	..	14.3	....	48 50 S	2	14.3	....	.2424	2	D4	189.1234†	338,79	16	M	o
556CIV	53 54 S	321 46	Do.	16.3	....	3 05 W	1	....	....	....	..	....	....	......	..	C1	....	84	12	M	f
557CIV	53 54 S	322 05	Do.	17.1	....	3 37 W	2	....	....	....	..	....	....	......	..	D4	....	90	21	M	ofb
558CIV[1]	54 16 S	323 38	Jan 12	8.9	....	4 43 W	1	....	....	....	..	....	....	......	..	C1	....	180	6	S	m
559CIV	54 14 S	325 27	Jan 15	5.0	....	5 46 W	2	....	....	....	..	....	....	......	..	C1, D4	....	90	29	R	bc
560CIV	54 14 S	326 03	Do.	7.7	....	6 13 W	2	....	....	....	..	....	....	......	..	C1, D4	....	158	19	R	bc
561CIV	54 17 S	327 51	Do.	....	....	....	..	14.9	....	50 01 S	2	14.9	....	.2337	2	D4	E13,189.1234†	96	13	R	bo
562CIV	54 19 S	328 38	Do.	18.5	....	7 41 W	2	....	....	....	..	....	....	......	..	C1	....	101	22	R	o
563CIV	54 41 S	332 02	Jan 16	14.4	....	10 37 W	0	....	....	....	..	....	....	......	..	C1	....	101	10	M	d
564CIV	54 42 S	332 10	Do.	....	....	....	..	15.1	....	51 07 S	2	15.1	....	.2299	2	D4	E13,189.1234†	101	10	M	r
565CIV	54 34 S	334 48	Jan 17	8.3	....	12 06 W	1	....	....	....	..	....	....	......	..	C1	....	124	11	M	m
566CIV	54 36 S	336 33	Do.	....	....	....	..	14.5	....	52 52 S	2	14.6	....	.2199	2	D4	E13,189.1234†	101	14	R	f

[1] From January 12 to January 14 the *Carnegie* was at South Georgia.

CRUISE IV, SOUTHERN OCEAN, 1915–1916—*Continued.*

	° ′	° ′	*1916*	h	h	° ′		h	h	° ′		h	h	c. g. s.				°	°		
567CIV	54 32 S	342 12	Jan 18	....	....	....	..	14.8	....	54 14 S	2	14.8	....	0.2140	2	D4	EI3,189.1234†	101	11	M	m
568CIV	54 30 S	344 22	Jan 19	9.8	....	17 22 W	1	....	....	....	..	....	....	......	..	C1	....	146	14	M	f
569CIV	54 29 S	345 19	Do.	14.3	....	17 26 W	1	....	....	....	..	....	....	......	..	C1	....	101	16	M	o
570CIV	54 28 S	345 25	Do.	....	....	....	..	14.8	....	54 59 S	2	14.8	....	.2116	2	D4	EI3,189.1234†	101	15	M	m
571CIV	54 19 S	349 48	Jan 20	11.4	....	19 58 W	1	....	....	....	..	....	....	......	..	C1	....	90	8	MR	f
572CIV	54 18 S	350 28	Do.	14.0	....	20 25 W	1	....	....	....	..	....	....	......	..	C1	....	107	11	M	m
573CIV	54 18 S	350 51	Do.	....	....	....	..	15.2	....	56 50 S	2	15.4	....	.2036	2	D4	EI3,189.1234†	107	11	M	om
574CIV	54 17 S	351 24	Do.	17.3	....	20 08 W	2	....	....	....	..	....	....	......	..	C1	....	79	11	M	f
575CIV	54 16 S	357 17	Jan 21	....	....	....	..	14.9	....	58 56 S	2	14.9	....	.1957	1	D4	EI3,189.1234†	112–68	21	R	o
576CIV	53 53 S	358 10	Do.	19.3	....	22 48 W	2	....	....	....	..	....	....	......	..	C1	....	22	15	MR	o
577CIV	53 45 S	358 37	Do.	22.4	....	24 19 W	2	....	....	....	..	....	....	......	..	C1	....	90	19	MR	bc
578CIV	53 41 S	0 39	Jan 22	7.4	....	25 09 W	2	....	....	....	..	....	....	......	..	C1, D4	....	22	26	M	bc
579CIV	54 21 S	2 16	Do.	....	....	....	..	15.5	....	60 27 S	2	15.4	....	.1878	2	D4	EI3,189.1234†	136	20	R	bc
580CIV	54 22 S	2 36	Do.	16.4	....	24 39 W	1	....	....	....	..	....	....	......	..	C1	....	118	20	MR	o
581CIV	53 48 S	4 19	Jan 23	5.6	....	25 19 W	2	....	....	....	..	....	....	......	..	C1	....	62	19	MR	c
582CIV	53 32 S	6 00	Do.	....	....	....	..	14.5	....	61 37 S	2	14.6	....	.1816	2	D4	EI3,189.1234†	112	22	M	bc
583CIV	53 32 S	6 21	Do.	16.4	....	26 13 W	1	....	....	....	..	....	....	......	..	C1	....	112	14	M	c
584CIV	53 39 S	9 22	Jan 24	10.3	....	27 10 W	1	....	....	....	..	....	....	......	..	C1	....	146	18	M	bc
585CIV	53 44 S	10 28	Do.	....	....	....	..	14.9	....	62 53 S	2	14.9	....	.1765	2	D4	EI3,189.1234†	124	20	MR	bc
586CIV	53 47 S	10 54	Do.	16.8	....	26 58 W	2	....	....	....	..	....	....	......	..	C1, D4	....	158	15	M	bc
587CIV	54 03 S	14 35	Jan 25	8.0	....	28 31 W	1	....	....	....	..	....	....	......	..	C1	....	118	20	M	bc
588CIV	54 13 S	16 08	Do.	....	....	....	..	14.6	....	64 24 S	2	14.6	....	.1716	2	D4	EI3,189.1234†	135	9	M	bc
589CIV	54 16 S	16 30	Do.	16.2	....	28 24 W	1	....	....	....	..	....	....	......	..	C1	....	124	15	MR	c
590CIV	54 33 S	19 55	Jan 26	6.8	....	28 46 W	2	....	....	....	..	....	....	......	..	C1, D4	....	180	27	M	bc
591CIV	54 28 S	22 00	Do.	....	....	....	..	14.9	....	65 46 S	2	14.8	....	.1642	2	D4	EI3,189.1234†	112	15	M	o
592CIV	54 27 S	22 16	Do.	15.8	....	29 08 W	1	....	....	....	..	....	....	......	..	C1	....	112	15	MR	c
593CIV	54 15 S	26 16	Jan 27	9.5	....	29 40 W	1	....	....	....	..	....	....	......	..	C1	....	124	12	M	s
594CIV	54 17 S	26 57	Do.	....	....	....	..	14.9	....	66 34 S	3	14.9	....	.1618	2	D4	EI3,189.1234†	114	8	M	f
595CIV	53 56 S	29 43	Jan 28	7.0	....	29 28 W	1	....	....	....	..	....	....	......	..	C1	....	45	30	MR	c
596CIV	53 33 S	31 35	Do.	....	....	....	..	14.7	....	66 57 S	2	14.7	....	.1597	2	D4	EI3,189.1234†	101	30	MR	bc
597CIV	53 25 S	32 12	Do.	17.0	....	29 29 W	2	....	....	....	..	....	....	......	..	C1, D4	....	101	22	M	bc
598CIV	52 55 S	34 55	Jan 29	5.8	....	30 35 W	2	....	....	....	..	....	....	......	..	C1	....	101	16	M	bc
599CIV	52 51 S	35 19	Do.	7.5	....	30 13 W	2	....	....	....	..	....	....	......	..	C1, D4	....	158	16	M	bc
600CIV	52 34 S	37 26	Do.	....	....	....	..	15.2	....	67 28 S	2	15.2	....	.1566	1	D4	EI3,189.1234†	108	12	R	c
601CIV	52 46 S	38 40	Jan 30	7.8	....	31 15 W	2	....	....	....	..	....	....	......	..	C1, D4	....	158	19	R	bc
602CIV	52 44 S	39 30	Do.	....	....	....	..	15.0	....	67 55 S	1	15.0	....	.1562	2	D4	EI3,189.1234†	101	22	R	bo
603CIV	52 42 S	39 52	Do.	17.4	....	32 02 W	3	....	....	....	..	....	....	......	..	C1, D4	....	101	9	R	bc
604CIV	51 53 S	42 33	Jan 31	9.4	....	31 30 W	1	....	....	....	..	....	....	......	..	C1	....	152	18	MR	c
605CIV	51 23 S	43 37	Do.	....	....	....	..	14.8	....	67 59 S	2	14.8	....	.1560	2	D4	EI3,189.1234†	79	18	R	o
606CIV	51 10 S	44 02	Do.	16.7	....	31 17 W	2	....	....	....	..	....	....	......	..	C1	....	79	24	MR	bc
607CIV	50 06 S	46 23	Feb 1	6.6	....	30 47 W	2	....	....	....	..	....	....	......	..	C1	....	68	14	MR	c
608CIV	49 29 S	47 48	Do.	....	....	....	..	15.0	....	67 42 S	2	14.9	....	.1581	2	D4	EI3,189.1234†	90	12	R	o
609CIV	49 18 S	48 17	Do.	16.8	....	30 57 W	2	....	....	....	..	....	....	......	..	C1	....	90	18	MR	c
610CIV	48 36 S	50 00	Feb 2	7.0	....	30 55 W	2	....	....	....	..	....	....	......	..	C1	....	68	27	MR	c
611CIV	48 36 S	51 26	Do.	....	....	....	..	14.6	....	67 50 S	2	14.6	....	.1582	2	D4	EI3,189.1234†	124	14	M	bc
612CIV	48 35 S	51 58	Do.	17.5	....	31 43 W	2	....	....	....	..	....	....	......	..	C1	....	124	30	M	c
613CIV	48 35 S	52 13	Do.	18.9	....	31 49 W	1	....	....	....	..	....	....	......	..	C1	....	124	23	M	c
614CIV	48 34 S	54 00	Feb 3	5.4	....	32 07 W	2	....	....	....	..	....	....	......	..	C1, D4	....	96	20	M	bc
615CIV	48 34 S	55 43	Do.	....	....	....	..	15.0	....	67 31 S	2	15.0	....	.1627	3	D4	EI3,189.1234†	124	12	M	o
616CIV	48 34 S	56 08	Do.	16.9	....	32 27 W	2	....	....	....	..	....	....	......	..	C1, D4	....	112	18	M	bc
617CIV	48 44 S	60 23	Feb 4	13.3	....	34 58 W	1	....	....	....	..	....	....	......	..	C1	....	135	10	M	c
618CIV	48 44 S	60 30	Do.	....	....	....	..	14.7	....	67 56 S	3	14.8	....	.1656	3	D4	EI3,189.1234†	135	9	M	o
619CIV	48 48 S	60 59	Do.	17.1	....	35 07 W	2	....	....	....	..	....	....	......	..	C1	....	112	10	M	o
620CIV	49 00 S	63 29	Feb 5	10.6	....	34 30 W	1	....	....	....	..	....	....	......	..	C1	....	158	11	M	c
621CIV	49 03 S	64 08	Do.	....	....	....	..	14.8	....	68 05 S	3	14.8	....	.1686	3	D4	EI3,189.1234†	135	16	M	b
622CIV	49 05 S	64 35	Do.	18.2	....	36 04 W	3	....	....	....	..	....	....	......	..	C1, D4	....	158	16	M	bc
623CIV	49 24 S	66 12	Feb 6	7.7	....	37 44 W	2	....	....	....	..	....	....	......	..	C1	....	169	10	M	c
624CIV	49 39 S	67 55	Do.	....	....	....	..	15.0	....	68 39 S	2	15.0	....	.1705	2	D4	EI3,189.1234†	141	12	M	o
625CIV	50 09 S	68 01	Do.	18.7	....	38 32 W	3	....	....	....	..	....	....	......	..	C1, D4	....	158	18	M	bc

FINAL RESULTS OF OCEAN MAGNETIC OBSERVATIONS ON THE CARNEGIE, 1915–1921—*Continued.*

CRUISE IV, SOUTHERN OCEAN, 1915–1916—*Continued.*

Station	Lat.	Long. East of Gr.	Date	Declination L. M. T.		Declination Value	Wt.	Inclination L. M. T.		Inclination Value	Wt.	Hor. intensity L. M. T.		Hor. intensity Value	Wt.	Instruments Compass	Instruments Dip Circle	Remarks Course	Remarks Roll	Remarks Sea	Weather
	° ′	° ′	*1916*	h	h	° ′		h	h	° ′		h	h	c. g. s.				°	°		
626CIV	50 38 S	69 35	Feb 7	6.9	....	39 35 W	2	....	....	....	..	....	....	......	..	C1, D4	....	191	35	R	bc
627CIV	51 14 S	71 30	Do.	....	....	....	..	15.2	....	69 20 S	2	15.1	....	0.1705	2	D4	EI3,189.12¾†	158	20	R	o
628CIV	51 26 S	72 10	Do.	18.3	....	40 34 W	2	....	....	....	..	....	....	......	..	C1, D4	....	158	31	R	c
629CIV	51 42 S	73 22	Feb 8	5.4	....	41 31 W	2	....	....	....	..	....	....	......	..	C1, D4	....	191	31	R	bc
630CIV	52 19 S	75 36	Do.	15.0	....	43 05 W	1	15.0	....	70 24 S	2	15.1	....	.1701	2	C1, D4	EI3,189.12¾†	180,158	18	R	bc
631CIV	52 28 S	76 29	Do.	19.2	....	41 44 W	2	....	....	....	..	....	....	......	..	C1	....	79	11	M	c
632CIV	51 41 S	77 12	Feb 9	6.8	....	41 32 W	3	....	....	....	..	....	....	......	..	C1, D4	....	79	21	MR	c
633CIV	50 47 S	78 14	Do.	....	....	....	..	14.9	....	70 37 S	3	14.9	....	.1688	2	D4	EI3,189.12¾†	79	15	M	bc
634CIV	50 28 S	78 38	Do.	17.9	....	42 20 W	3	....	....	....	..	....	....	......	..	C1, D4	....	79	14	M	bc
635CIV	49 26 S	80 49	Feb 10	....	....	....	..	14.7	....	71 08 S	2	14.7	....	.1682	2	D4	EI3,189.12¾†	80	10	M	or
636CIV	49 11 S	81 10	Do.	16.6	....	40 08 W	2	....	....	....	..	....	....	......	..	C1	....	79	33	R	rs
637CIV	49 06 S	81 16	Do.	17.4	....	41 53 W	2	....	....	....	..	....	....	......	..	C1, D4	....	79	33	R	rfs
638CIV	47 38 S	82 58	Feb 11	7.6	....	39 12 W	2	....	....	....	..	....	....	......	..	C1, D4	....	45	16	M	bc
639CIV	46 52 S	83 59	Do.	....	....	....	..	14.8	....	70 49 S	2	14.7	....	.1717	2	D4	EI3,189.12¾†	68	24	R	bc
640CIV	46 35 S	84 16	Do.	16.8	....	37 58 W	2	....	....	....	..	....	....	......	..	C1, D4	....	68	30	R	bc
641CIV	44 39 S	85 58	Feb 12	8.1	....	35 52 W	2	....	....	....	..	....	....	......	..	C1, D4	....	45	18	M	bc
642CIV	43 49 S	86 47	Do.	....	....	....	..	14.7	....	70 16 S	3	14.7	....	.1782	2	D4	EI3,189.12¾†	62	18	M	bq
643CIV	43 32 S	87 02	Do.	16.9	....	34 19 W	2	....	....	....	..	....	....	......	..	C1, D4	....	62	14	ML	c
644CIV	41 47 S	88 12	Feb 13	7.1	....	30 44 W	2	....	....	....	..	....	....	......	..	C1, D4	....	22	20	R	bc
645CIV	40 59 S	88 43	Do.	....	....	....	..	14.8	....	69 31 S	2	14.8	....	.1861	2	D4	EI3,189.12¾†	56	22	M	o
646CIV	40 48 S	88 51	Do.	16.4	....	30 19 W	2	....	....	....	..	....	....	......	..	C1, D4	....	22	20	R	bc
647CIV	40 33 S	88 58	Do.	18.8	....	29 46 W	2	....	....	....	..	....	....	......	..	C1, D4	....	45	15	M	bc
648CIV	39 02 S	89 49	Feb 14	6.6	....	28 00 W	3	....	....	....	..	....	....	......	..	C1, D4	....	56	11	M	bc
649CIV	37 58 S	90 43	Do.	....	....	....	..	14.7	....	68 35 S	3	14.7	....	.1951	2	D4	EI3,189.12¾†	56	12	R	bc
650CIV	37 45 S	90 53	Do.	16.3	....	25 34 W	2	....	....	....	..	....	....	......	..	C1	....	51	14	M	c
651CIV	37 34 S	91 02	Do.	17.7	....	26 25 W	3	....	....	....	..	....	....	......	..	C1, D4	....	56	10	M	bc
652CIV	35 58 S	92 32	Feb 15	7.9	....	22 58 W	2	....	....	....	..	....	....	......	..	C1	....	62	6	M	c
653CIV	35 41 S	93 33	Do.	14.9	....	22 36 W	1	14.9	....	67 52 S	3	14.9	....	.2016	3	C1, D4	EI3,189.12¾†	90	10	M	bc
654CIV	35 32 S	93 56	Do.	17.7	....	21 49 W	3	....	....	....	..	....	....	......	..	C1, D4	....	56	8	M	bc
655CIV	34 55 S	95 20	Feb 16	5.9	....	20 29 W	3	....	....	....	..	....	....	......	..	C1, D4	....	68	10	S	bc
656CIV	34 22 S	96 13	Do.	....	....	....	..	14.7	....	67 06 S	3	14.7	....	.2107	3	D4	EI3,189.12¾†	69	7	M	bc
657CIV	34 09 S	96 23	Do.	17.1	....	18 38 W	3	....	....	....	..	....	....	......	..	C1, D4	....	45	8	M	bc
658CIV	34 54 S	95 36	Feb 17	9.7	....	20 38 W	1	....	....	....	..	....	....	......	..	C1	....	202	10	M	c
659CIV	35 09 S	95 30	Do.	....	....	....	..	15.1	....	67 29 S	2	15.1	....	.2080	2	D4	EI3,189.12¾†	214	11	S	o
660CIV	36 11 S	95 23	Feb 18	15.8	....	21 53 W	1	14.2	....	68 05 S	3	14.2	....	.2026	3	C1, D4	189.12¾†	169	14	S	c
661CIV	36 10 S	96 58	Feb 19	10.1	....	21 05 W	1	....	....	....	..	....	....	......	..	C1	....	124	10	S	c
662CIV	35 58 S	97 29	Do.	....	....	....	..	16.0	....	68 16 S	3	16.0	....	.2024	3	D4	189.12¾†	84	7	S	bc
663CIV	35 56 S	97 34	Do.	16.9	....	20 02 W	3	....	....	....	..	....	....	......	..	C1, D4	....	84	10	S	bm
664CIV	36 02 S	97 36	Do.	18.8	....	19 46 W	3	....	....	....	..	....	....	......	..	C1, D4	....	202	8	S	z
665CIV	37 12 S	97 28	Feb 20	9.6	....	21 29 W	1	....	....	....	..	....	....	......	..	C1	....	202	9	S	c
666CIV	37 44 S	97 32	Do.	....	....	....	..	15.2	....	69 12 S	3	15.2	....	.1964	3	D4	EI3,189.12¾†	202	20	M	o
667CIV	38 02 S	97 34	Do.	17.8	....	22 13 W	3	....	....	....	..	....	....	......	..	C1, D4	....	202	11	M	bc
668CIV	39 22 S	98 28	Feb 21	6.4	....	22 59 W	3	....	....	....	..	....	....	......	..	C1, D4	....	169	10	R	bq
669CIV	39 57 S	99 24	Do.	....	....	....	..	14.8	....	70 52 S	2	14.8	....	.1870	2	D4	EI3,189.12¾†	159	16	R	bc
670CIV	40 04 S	99 35	Do.	16.6	....	23 40 W	2	....	....	....	..	....	....	......	..	C1, D4	....	180	16	MR	bc
671CIV	41 48 S	100 18	Feb 22	8.9	....	25 39 W	1	....	....	....	..	....	....	......	..	C1	....	202	14	MR	o
672CIV	42 43 S	100 31	Do.	....	....	....	..	14.8	....	72 16 S	2	14.7	....	.1734	2	D4	EI3,189.12¾†	202	14	R	bc
673CIV	43 07 S	100 36	Do.	16.9	....	26 10 W	2	....	....	....	..	....	....	......	..	C1	....	202	14	R	c
674CIV	46 31 S	101 36	Feb 23	....	....	....	..	14.8	....	74 20 S	2	14.8	....	.1594	2	D4	EI3,189.12¾†	214	14	R	od
675CIV	46 48 S	101 43	Do.	18.3	....	31 47 W	2	....	....	....	..	....	....	......	..	C1, D4	....	214	27	R	c
676CIV	47 39 S	101 58	Feb 24	6.9	....	32 38 W	2	....	....	....	..	....	....	......	..	C1	....	214	18	MR	c

CRUISE IV, SOUTHERN OCEAN, 1915–1916—*Continued.*

	° ′	° ′	1916	h	h	° ′		h	h	° ′		h	h	c.g.s.				°	°		
677CIV	47 58 S	102 03	Feb 24					14.7		75 08 S	2	14.7		0.1534	2	D4	EI3,189.1234†	214	16	M	o
678CIV	47 58 S	102 04	Do.	16.3		33 23 W	2									C1, D4		214	20	M	bc
679CIV	47 55 S	102 56	Feb 25	6.6		33 03 W	3									C1, D4		112	13	M	bc
680CIV	47 48 S	103 50	Do.					15.0		75 23 S	3	15.0		.1530	2	D4	EI3,189.1234†	134	10	S	bc
681CIV	47 51 S	104 08	Do.	17.7		30 17 W	3									C1, D4		146	12	M	bc
682CIV	49 13 S	104 25	Feb 26	6.8		33 41 W	3									C1, D4		191	10	M	bc
683CIV	50 18 S	105 05	Do.					14.8		76 29 S	2	14.8		.1419	2	D4	EI3,189.1234†	195	23	R	oq
684CIV	50 35 S	105 19	Do.	16.6		34 22 W	2									C1, D4		191	22	R	qr
685CIV	52 04 S	106 16	Feb 27	7.0		36 30 W	2									C1, D4		202	20	R	bq
686CIV	52 50 S	106 49	Do.					14.9		78 06 S	1	14.8		.1289	1	D4	EI3,189.1234†	197	25	R	oq
687CIV	53 03 S	107 02	Do.	16.7		37 53 W	2									C1, D4		202	25	R	bq
688CIV	54 13 S	107 29	Feb 28	9.9		40 23 W	2									C1		225	16	M	o
689CIV	54 59 S	107 38	Do.					14.8		78 58 S	2	14.8		.1214	2	D4	EI3,189.1234†	225	17	M	md
690CIV[1]	57 10 S	108 17	Feb 29	6.7		45 53 W	2									C1, D4		248	11	R	bqr
691CIV	57 17 S	108 36	Do.					14.5		79 52 S	1	14.5		.1134	1	D4	189.1234†	225	20	R	cq
692CIV	57 31 S	108 44	Do.	16.6		45 39 W	2									C1, D4		225	22	R	bc
693CIV	58 49 S	109 20	Mar 1	7.6		49 38 W										C1		202	18	M	qs
694CIV	58 59 S	109 36	Do.	9.3		49 42 W	2									C1		197	17	M	qs
695CIV	59 24 S	110 21	Do.					14.8		80 30 S	2	14.8		.1045	2	D4	EI3,189.1234†	158	27	M	qs
696CIV	59 24 S	110 24	Do.	14.9		50 34 W	1									C1		169	16	M	c
697CIV	59 17 S	110 51	Do.	17.8		50 28 W	3									C1, D4		68	18	M	bc
698CIV	57 46 S	111 59	Mar 2	5.9		44 34 W	3									C1, D4		68	9	M	bc
699CIV	56 22 S	112 32	Do.					16.0		80 19 S	2	16.0		.1077	2	D4	EI3,189.1234†	45	20	R	c
700CIV	56 18 S	112 33	Do.	16.4		41 48 W	2									C1		45	20	M	c
701CIV	54 32 S	113 24	Mar 3	6.2		36 15 W	2									C1, D4		45	22	M	bc
702CIV	53 26 S	113 50	Do.					14.8		79 25 S	3	14.8		.1190	3	D4	EI3,189.1234†	45	16	M	o
703CIV	53 25 S	113 51	Do.	15.0		32 02 W	2									C1		45	16	M	c
704CIV	53 02 S	114 04	Do.	18.2		31 11 W	1									C1		45	16	M	o
705CIV	51 34 S	115 56	Mar 4	9.9		25 55 W	1									C1		112	10	M	c
706CIV	51 29 S	117 02	Do.					14.8		79 18 S	2	14.7		.1201	2	D4	EI3,189.1234	107	12	MR	or
707CIV	51 27 S	117 34	Do.	16.8		23 10 W	2									C1		90	12	M	c
708CIV	49 43 S	119 50	Mar 5	8.2		17 26 W	2									C1		22	25	M	c
709CIV	48 52 S	120 37	Do.					14.9		77 59 S	2	14.9		.1364	2	D4	EI3,189.1234†	45	18	R	bcq
710CIV	48 36 S	120 53	Do.	16.9		14 47 W	2									C1, D4		34	30	R	bq
711CIV	46 46 S	122 28	Mar 6	6.6		10 24 W	3									C1, D4		34	13	R	bcq
712CIV	45 42 S	123 18	Do.					15.2		75 58 S	1	15.2		.1541	1	D4	EI3,189.1234	42	22	R	bcqr
713CIV	45 11 S	124 56	Mar 7	7.3		6 05 W	2									C1, D4		22	35	R	bq
714CIV[1]	45 08 S	125 12	Do.					14.2		75 23 S	1	14.2		.1598	1	D4	189.1234†	0	35	R	oq
715CIV	45 00 S	125 53	Mar 8	8.3		5 37 W	2									C1, D4		22	18	R	bq
716CIV[1]	44 58 S	126 04	Do.					14.4		75 29 S	1	14.3		.1614	1	D4	189.1234†	6	25	R	bcq
717CIV	44 58 S	126 09	Do.	17.0		4 58 W	3									C1, D4		0	18	R	bq
718CIV	44 44 S	126 23	Mar 9	6.8		4 54 W	3									C1, D4		11	24	R	qr
719CIV	43 58 S	126 37	Do.					14.5		74 37 S	2	14.4		.1681	2	D4	EI3,189.1234†	0	30	MR	bcq
720CIV	43 44 S	126 40	Do.	16.8		3 58 W	2									C1, D4		0	17	R	bc
721CIV	42 05 S	127 36	Mar 10	9.6		2 23 W	1									C1		90	13	MR	c
722CIV	41 36 S	127 59	Do.					15.1		72 47 S	2	15.1		.1851	2	D4	EI3,189.1234†	17	35	R	oq
723CIV	41 32 S	128 03	Do.	16.0		0 45 W	2									C1		17	25	MR	c
724CIV	40 26 S	128 59	Mar 11	6.3		0 27 W	3									C1, D4		22	14	M	q
725CIV	40 21 S	129 01	Do.	7.0		0 20 W	3									C1, D4		11	14	M	q
726CIV	39 42 S	129 26	Do.					14.8		71 05 S	3	14.8		.2019	3	D4	EI3,189.1234†	34	11	M	o
727CIV	39 39 S	129 28	Do.	15.2		0 10 E	1									C1		45	10	MS	c
728CIV	39 29 S	129 45	Do.	20.0		0 18 E	2									C1		56	6	S	c
729CIV	39 57 S	129 57	Mar 12	6.3		0 20 E	3									C1, D4		169	7	M	bc
730CIV	40 43 S	130 06	Do.					14.6		71 49 S	3	14.6		.1930	3	D4	EI3,189.1234†	180	10	M	bc
731CIV	40 49 S	130 06	Do.	15.5		0 07 E	2									C1, D4		180	17	MS	bc
732CIV	41 01 S	130 08	Do.	17.2		0 13 E	3									C1, D4		180	10	M	bc
733CIV	42 27 S	130 51	Mar 13	6.3		0 10 E	3									C1, D4		158	12	M	bc
734CIV	43 30 S	130 58	Do.					15.2		73 52 S	3	15.2		.1749	2	D4	EI3,189.1234†	191	15	M	bc
735CIV	43 50 S	130 55	Do.	17.3		0 14 W	3									C1, D4		191	12	M	cq

[1] Hove to in a gale.

FINAL RESULTS OF OCEAN MAGNETIC OBSERVATIONS ON THE CARNEGIE, 1915–1921—*Continued.*

CRUISE IV, SOUTHERN OCEAN, 1915–1916—*Concluded.*

Station	Lat.	Long. East of Gr.	Date	Declination L. M. T.	Declination Value	Declination Wt.	Inclination L. M. T.	Inclination Value	Inclination Wt.	Hor. intensity L. M. T.	Hor. intensity Value	Hor. intensity Wt.	Instruments Compass	Instruments Dip Circle	Remarks Course	Remarks Roll	Remarks Sea	Remarks Weather
	° ′	° ′	1916	h	° ′		h	° ′		h	c. g. s.				°	°		
736CIV	45 41 S	130 50	Mar 14	6.8	0 43 W	3	....	....	..	....	......	..	C1, D4	....	191	10	M	bqr
737CIV	46 54 S	130 49	Do.	....	....	..	14.8	76 26 S	2	14.8	0.1526	2	D4	EI3,189.1234†	191	20	R	bcq
738CIV	47 08 S	130 51	Do.	16.4	1 11 W	2	....	....	..	....	......	..	C1, D4	....	188	20	M	bq
739CIV	48 24 S	132 19	Mar 15	7.7	1 16 W	2	....	....	..	....	......	..	C1, D4	....	141	24	M	o
740CIV	48 56 S	132 54	Do.	....	....	..	14.6	77 41 S	2	14.6	.1382	2	D4	189.1234†	197	11	MS	o
741CIV	49 09 S	132 50	Do.	16.4	1 10 W	2	....	....	..	....	......	..	C1	....	202	15	M	o
742CIV	50 20 S	132 56	Mar 16	6.9	1 49 W	2	....	....	..	....	......	..	C1, D4	....	180–202	22	M	bc
743CIV[1]	50 23 S	132 54	Do.	....	....	..	8.6 to 11.5	78 41 S	3	8.5 to 11.6	.1292	3	D4	189.1234†	Swing	12	MS	bco
744CIV	51 00 S	132 42	Do.	17.0	1 21 W	1	....	....	..	....	......	..	C1	....	202	20	M	o
745CIV	53 13 S	132 02	Mar 17	9.2	5 16 W	2	....	....	..	....	......	..	C1, D4	....	191	11	MR	bq
746CIV	54 11 S	131 54	Do.	....	....	..	15.2	80 53 S	1	15.1	.1061	1	D4	EI3,189.1234†	169	30	R	bc
747CIV	54 27 S	132 07	Do.	17.0	6 40 W	1	....	....	..	....	......	..	C1	....	169	20	MR	bc
748CIV	54 37 S	132 08	Do.	18.1	6 08 W	2	....	....	..	....	......	..	C1	....	169	20	MR	bc
749CIV[2]	56 36 S	132 54	Mar 18	9.5	8 56 W	1	....	....	..	....	......	..	C1	....	79–22	25	R	o
750CIV[2]	56 36 S	133 17	Do.	....	....	..	14.6	82 26 S	1	14.6	.0888	1	D4	189.1234†	51	30	R	bc
751CIV[2]	56 37 S	133 27	Do.	16.6	8 15 W	1	....	....	..	....	......	..	C1, D4	....	45	31	R	bq
752CIV	56 40 S	134 26	Mar 19	7.2	7 57 W	2	....	....	..	....	......	..	C1, D4	....	112	24	R	bc
753CIV	57 08 S	135 48	Do.	....	....	..	15.5	82 36 S	2	15.4	.0860	2	D4	EI3,189.1234†	180	26	MR	o
754CIV	57 13 S	135 50	Do.	16.0	4 38 W	2	....	....	..	....	......	..	C1, D4	....	180	30	R	bc
755CIV	57 25 S	135 53	Do.	17.6	5 19 W	2	....	....	..	....	......	..	C1, D4	....	180	30	R	b
756CIV	57 08 S	137 54	Mar 20	6.5	2 53 W	3	....	....	..	....	......	..	C1, D4	....	124	18	M	bc
757CIV	57 11 S	138 57	Do.	....	....	..	15.2	82 20 S	2	15.1	.0885	2	D4	EI3,189.1234†	90	30	MSL	bc
758CIV	57 12 S	139 10	Do.	16.6	0 11 E	2	....	....	..	....	......	..	C1	....	90	17	ML	o
759CIV	56 57 S	142 07	Mar 21	8.5	4 26 E	2	....	....	..	....	......	..	C1	....	79	8	S	md
760CIV	56 50 S	143 28	Do.	....	....	..	14.7	82 02 S	3	14.7	.0938	3	D4	EI3,189.1234†	73	10	MS	o
761CIV	56 52 S	144 33	Mar 22	8.2	6 49 E	2	....	....	..	....	......	..	C1	....	281,62	10	M	d
762CIV	56 45 S	144 51	Do.	....	....	..	14.6	81 34 S	2	14.6	.0977	2	D4	EI3,189.1234†	56	13	MRL	ofm
763CIV	56 41 S	146 57	Mar 23	8.4	11 43 E	2	....	....	..	....	......	..	C1	....	68	6	S	r
764CIV	56 32 S	147 24	Do.	....	....	..	14.7	81 13 S	2	14.7	.1042	2	D4	EI3,189.1234†	34	20	M	omd
765CIV	54 35 S	150 40	Mar 24	10.3	14 18 E	1	....	....	..	....	......	..	C1	....	79	20	ML	o
766CIV	54 10 S	151 30	Do.	....	....	..	15.0	79 01 S	2	15.0	.1272	2	D4	EI3,189.1234†	34	16	RL	bc
767CIV	54 09 S	151 32	Do.	15.0	13 52 E	2	....	....	..	....	......	..	C1.	....	34	20	ML	o
768CIV	53 07 S	153 50	Mar 25	6.9	15 44 E	3	....	....	..	....	......	..	C1, D4	....	22	12	M	bc
769CIV	52 47 S	154 37	Do.	....	....	..	14.8	78 01 S	3	14.7	.1378	3	D4	EI3,189.1234†	34	16	M	o
770CIV	52 41 S	156 22	Mar 26	10.5	15 57 E	1	....	....	..	....	......	..	C1	....	68	11	M	o
771CIV	52 30 S	156 54	Do.	....	....	..	14.6	77 16 S	3	14.6	.1454	3	D4	189.1234†	34	16	S	bco
772CIV	51 26 S	159 54	Mar 27	7.8	17 32 E	3	....	....	..	....	......	..	C1, D4	....	68	16	M	bc
773CIV	50 43 S	161 14	Do.	....	....	..	14.6	75 06 S	2	14.6	.1633	2	D4	189.1234†	22	18	R	bc
774CIV	50 30 S	161 34	Do.	16.6	17 43 E	2	....	....	..	....	......	..	C1, D4	....	22,17	19	R	bc
775CIV	48 49 S	163 29	Mar 28	7.9	17 22 E	2	....	....	..	....	......	..	C1, D4	....	0	22	M	bc
776CIV	48 28 S	164 33	Do.	....	....	..	15.0	73 10 S	2	15.0	.1836	2	D4	189.1234†	68	20	M	bc
777CIV	48 27 S	164 44	Do.	16.1	17 31 E	3	....	....	..	....	......	..	C1, D4	....	56	12	M	bc
778CIV	48 12 S	167 08	Mar 29	8.3	17 46 E	3	....	....	..	....	......	..	C1, D4	....	79	16	M	bc
779CIV	47 40 S	168 10	Do.	....	....	..	14.4	71 54 S	3	14.4	.1931	3	D4	EI3,189.1234†	34	10	M	o
780CIV	47 13 S	169 15	Do.	21.7	17 59 E	2	....	....	..	....	......	..	C1	....	34	6	S	bc
781CIV	46 39 S	170 32	Mar 30	7.0	18 15 E	3	....	....	..	....	......	..	C1, D4	....	11	3	S	bc
782CIV	45 58 S	171 14	Do.	....	....	..	14.4	70 11 S	3	14.4	.2080	3	D4	EI3,189.1234†	11	6	S	bc
783CIV	45 50 S	171 22	Do.	16.9	17 46 E	3	....	....	..	....	......	..	C1, D4	....	22	2	S	bc
784CIV	44 59 S	172 31	Mar 31	7.1	17 37 E	3	....	....	..	....	......	..	C1, D4	....	22	3	S	o
785CIV	44 44 S	172 57	Do.	....	....	..	14.4	68 52 S	3	14.4	.2184	3	D4	189.1234†	349	9	S	o
786CIV	44 31 S	173 04	Do.	17.1	17 23 E	3	....	....	..	....	......	..	C1, D4	....	349	4	S	b
787CIV[3]	43 38 S	173 08	Apr 1	6.7	17 08 E	3	....	....	..	....	......	..	C1, D4	....	281	2	S	bc

[1] Swinging ship at sea. [2] Hove to in a gale. [3] Between April 1 and May 17 the *Carnegie* was at Lyttelton.

CRUISE IV, PACIFIC OCEAN, 1916–1917.

	° ′	° ′	1916	h	h	° ′		h	h	° ′		h	h	c. g. s.				°	°		
788CIV[1]	43 32 S	172 48	May 10	7.2 to	10.1	17 01 E	3	10.2 to	16.9	67 56 S	3	10.2 to	17.0	0.2244	3	C1, D4	189.1234†	Swing	1	S	bc
789CIV	43 33 S	172 56	May 17	16.0	....	16 17 E	3	....	....	....	..	....	....	......	..	C1, D4	....	338	5	S	b
790CIV	43 41 S	174 07	May 18	9.5	....	17 09 E	3	....	....	....	..	....	....	......	..	C1, D4	....	79	5	S	bc
791CIV	43 54 S	174 40	Do.	....	....	....	..	14.6	....	67 56 S	3	14.6	....	.2230	3	D4	EI3,189.1234†	79	8	S	bc
792CIV	43 57 S	174 43	Do.	16.1	....	17 11 E	3	....	....	....	..	....	....	......	..	C1, D4	....	124	8	S	bc
793CIV	43 07 S	174 19	May 19	8.2	....	17 04 E	3	....	....	....	..	....	....	......	..	C1, D4	....	349	6	M	d
794CIV	42 58 S	174 13	Do.	....	....	....	..	14.5	....	67 27 S	3	14.5	....	.2294	3	D4	EI3,189.1234†	141	10	MS	mdf
795CIV	43 36 S	175 40	May 20	7.6	....	17 08 E	3	....	....	....	..	....	....	......	..	C1, D4	....	79	11	M	bc
796CIV	43 43 S	176 11	Do.	....	....	....	..	14.8	....	67 32 S	3	14.7	....	.2268	3	D4	EI3,189.1234†	107	13	M	bc
797CIV	43 59 S	176 34	May 21	8.0	....	17 34 E	3	....	....	....	..	....	....	......	..	C1, D4	....	79	9	M	bc
798CIV	43 55 S	176 55	Do.	....	....	....	..	14.4	....	67 40 S	3	14.4	....	.2255	3	D4	EI3,189.1234†	34	5	MS	bc
799CIV	43 55 S	177 40	May 22	7.5	....	17 31 E	3	....	....	....	..	....	....	......	..	C1, D4	....	73	6	M	bc
800CIV	44 10 S	178 51	Do.	....	....	....	..	14.4	....	67 29 S	2	14.4	....	.2253	2	D4	EI3,189.1234†	84	12	M	b
801CIV	44 14 S	179 08	Do.	16.0	....	17 37 E	3	....	....	....	..	....	....	......	..	C1, D4	....	79	9	M	bc
802CIV[2]	43 57 S	181 24	Do.	7.6	....	17 51 E	3	....	....	....	..	....	....	......	..	C1, D4	....	22	11	M	bc
803CIV	43 25 S	182 08	Do.	....	....	....	..	14.4	....	66 35 S	2	14.4	....	.2327	2	D4	EI3,189.1234†	11	11	M	b
804CIV	43 16 S	182 18	Do.	16.0	....	17 24 E	2	....	....	....	..	....	....	......	..	C1, D4	....	11	17	M	bc
805CIV	41 47 S	184 05	May 23	7.5	....	16 41 E	3	....	....	....	..	....	....	......	..	C1, D4	....	0	12	M	bc
806CIV	41 00 S	184 30	Do.	....	....	....	..	14.5	....	63 56 S	2	14.5	....	.2485	2	D4	EI3,189.1234†	0	12	M	bc
807CIV	40 50 S	184 36	Do.	16.3	....	16 37 E	3	....	....	....	..	....	....	......	..	C1, D4	....	0	8	M	bc
808CIV	39 57 S	185 39	May 24	7.6	....	16 41 E	3	....	....	....	..	....	....	......	..	C1, D4	....	11	8	M	bc
809CIV	39 45 S	185 47	Do.	....	....	....	..	14.6	....	62 37 S	2	14.6	....	.2574	2	D4	EI3,189.1234†	349	18	M	bc
810CIV	39 42 S	185 47	Do.	16.1	....	16 13 E	2	....	....	....	..	....	....	......	..	C1	....	349	12	M	bc
811CIV	37 26 S	186 25	May 25	7.2	....	15 41 E	2	....	....	....	..	....	....	......	..	C1, D4	....	0	8	M	c
812CIV	37 13 S	186 28	Do.	8.8	....	15 26 E	2	....	....	....	..	....	....	......	..	C1, D4	....	349	11	M	bc
813CIV	36 21 S	186 48	Do.	....	....	....	..	14.9	....	59 31 S	2	14.9	....	.2726	2	D4	EI3,189.1234†	11	11	M	bc
814CIV	35 59 S	187 01	Do.	17.4	....	15 10 E	2	....	....	....	..	....	....	......	..	C1	....	11	13	M	c
815CIV	34 06 S	187 18	May 26	7.8	....	14 13 E	3	....	....	....	..	....	....	......	..	C1, D4	....	338	10	M	bc
816CIV	33 18 S	187 21	Do.	....	....	....	..	14.3	....	56 19 S	3	14.3	....	.2882	3	D4	EI3,189.1234†	343	10	M	bc
817CIV	33 04 S	187 18	Do.	16.6	....	14 07 E	3	....	....	....	..	....	....	......	..	C1, D4	....	343	8	M	bc
818CIV	31 14 S	186 11	May 27	7.2	....	13 30 E	3	....	....	....	..	....	....	......	..	C1, D4	....	292	12	M	bc
819CIV	30 42 S	185 06	Do.	....	....	....	..	14.6	....	53 47 S	2	14.6	....	.2989	2	D4	EI3,189.1234†	276	18	R	bc
820CIV	30 59 S	186 02	May 28	8.2	....	13 35 E	2	....	....	....	..	....	....	......	..	C1	....	56	12	M	c
821CIV	30 58 S	186 26	Do.	....	....	....	..	14.5	....	54 04 S	2	14.5	....	.2985	2	D4	EI3,189.1234†	56	16	MR	c
822CIV	30 36 S	187 45	May 29	9.9	....	13 11 E	2	....	....	....	..	....	....	......	..	C1	....	79	12	M	c
823CIV	30 33 S	187 56	Do.	....	....	....	..	14.6	....	52 49 S	3	14.5	....	.3007	3	D4	EI3,189.1234†	25	10	M	c
824CIV	29 07 S	188 15	May 30	....	....	....	..	14.4	....	51 38 S	3	14.4	....	.3053	3	D4	EI3,189.1234†	34	9	M	cd
825CIV	28 56 S	188 48	May 31	7.4	....	13 04 E	3	....	....	....	..	....	....	......	..	C1, D4	....	68	7	M	bc
826CIV	28 42 S	189 47	Do.	....	....	....	..	14.7	....	51 14 S	3	14.8	....	.3067	3	D4	189.1234†	65	7	M	bc
827CIV	28 41 S	189 54	Do.	15.6	....	13 16 E	2	....	....	....	..	....	....	......	..	C1, D4	....	56	8	S	bc
828CIV	27 19 S	191 30	Jun 1	7.6	....	12 26 E	3	....	....	....	..	....	....	......	..	C1, D4	....	0	12	M	bc
829CIV	26 32 S	191 36	Do.	....	....	....	..	14.4	....	47 37 S	2	14.4	....	.3174	2	D4	EI3,189.1234†	343	13	M	bc
830CIV	26 17 S	191 37	Do.	16.5	....	12 13 E	3	....	....	....	..	....	....	......	..	C1, D4	....	343	10	M	bc
831CIV	24 57 S	191 41	Jun 2	6.9	....	11 58 E	3	....	....	....	..	....	....	......	..	C1, D4	....	343	6	M	bc
832CIV	24 33 S	191 37	Do.	....	....	....	..	14.4	....	45 04 S	3	14.4	....	.3232	3	D4	EI3,189.1234†	338	8	M	cq
833CIV	24 24 S	191 34	Do.	16.7	....	11 47 E	3	....	....	....	..	....	....	......	..	C1, D4	....	338	20	ML	bc
834CIV	22 25 S	190 57	Jun 3[3]	....	....	....	..	14.4	....	42 25 S	2	14.4	....	.3295	2	D4	EI3,189.1234†	326	9	M	c
835CIV	22 22 S	190 56	Do.	14.7	....	11 33 E	2	....	....	....	..	....	....	......	..	C1	....	22	10	M	c
836CIV	19 30 S	190 04	Jun 4	....	....	....	..	14.5	....	38 22 S	2	14.5	....	.3396	2	D4	189.1234†	56	25	ML	rq
837CIV	18 45 S	189 05	Jun 5	6.8	....	10 38 E	3	....	....	....	..	....	....	......	..	C1, D4	....	0	9	M	bc
838CIV	18 27 S	189 05	Do.	....	....	....	..	14.9	....	36 26 S	3	14.9	....	.3450	3	D4	EI3,189.1234†	0	13	S	b
839CIV	18 23 S	189 05	Do.	16.6	....	10 25 E	3	....	....	....	..	....	....	......	..	C1, D4	....	349	9	M	bc
840CIV	16 08 S	189 31	Jun 6	....	....	....	..	14.4	....	32 37 S	1	14.4	....	.3482	1	D4	EI3,189.1234†	6	19	MR	cqr
841CIV	16 04 S	189 32	Do.	16.6	....	9 49 E	2	....	....	....	..	....	....	......	..	C1, D4	....	0	30	R	bq
842CIV[3]	14 37 S	189 33	Jun 7	8.9	....	9 54 E	1	....	....	....	..	....	....	......	..	C1	....	11	14	MR	q
843CIV	14 17 S	189 06	Jun 19	17.2	....	10 05 E	3	....	....	....	..	....	....	......	..	C1, D4	....	349	10	M	bc
844CIV	12 32 S	188 58	Jun 20	6.6	....	9 33 E	2	....	....	....	..	....	....	......	..	C1, D4	....	0	14	MR	bc

[1] Swinging ship off New Brighton Beach, N. Z.
[2] Date repeated on crossing the 180th meridian.
[3] Between June 7 and June 19 the *Carnegie* was at Pago Pago.

FINAL RESULTS OF OCEAN MAGNETIC OBSERVATIONS ON THE CARNEGIE, 1915–1921—*Continued.*

CRUISE IV, PACIFIC OCEAN, 1916–1917—*Continued.*

Station	Lat.	Long. East of Gr.	Date	Declination L. M. T.		Declination Value	Declination Wt.	Inclination L. M. T.		Inclination Value	Inclination Wt.	Hor. intensity L. M. T.		Hor. intensity Value	Hor. intensity Wt.	Instruments Compass	Instruments Dip Circle	Remarks Course	Remarks Roll	Remarks Sea	Wea-ther
	° ′	° ′	*1916*	*h*	*h*	° ′		*h*	*h*	° ′		*h*	*h*	*c. g. s.*				°	°		
845CIV	11 30 S	189 13	Jun 20	....	....	....	..	14.8	....	24 19 S	2	14.9	....	0.3557	2	D4	189.1234†	11	18	M	bo
846CIV	11 15 S	189 18	Do.	16.9	....	9 26 E	2	....	....	....	..	....	....	......	..	C1, D4	....	11	18	MR	bo
847CIV	9 34 S	189 28	Jun 21	8.4	....	8 56 E	2	....	....	....	..	....	....	......	..	C1, D4	....	11	12	M	bo
848CIV	9 04 S	189 20	Do.	....	....	....	..	14.9	....	19 38 S	2	14.9	....	.3562	2	D4	189.1234†	352	22	M	bo
849CIV	8 56 S	189 22	Do.	17.3	....	8 49 E	3	....	....	....	..	....	....	......	..	C1, D4	....	6	8	M	bc
850CIV	7 15 S	189 06	Jun 22	7.3	....	8 55 E	3	....	....	....	..	....	....	......	..	C1, D4	....	338	8	M	bo
851CIV	6 14 S	188 43	Do.	....	....	....	..	14.4	....	13 58 S	3	14.4	....	.3584	3	D4	EI3,189.1234†	338	10	M	bo
852CIV	5 51 S	188 35	Do.	17.3	....	8 38 E	3	....	....	....	..	....	....	......	..	C1, D4	....	309	12	M	bo
853CIV	4 19 S	188 01	Jun 23	7.1	....	8 56 E	3	....	....	....	..	....	....	......	..	C1, D4	....	349	9	M	bo
854CIV	3 23 S	187 50	Do.	....	....	....	..	14.7	....	8 12 S	3	14.7	....	.3566	3	D4	EI3,189.1234†	346	16	MS	bo
855CIV	3 02 S	187 46	Do.	17.6	....	8 34 E	3	....	....	....	..	....	....	......	..	C1, D4	....	349	12	M	bo
856CIV	1 51 S	187 09	Jun 24	6.4	....	8 24 E	3	....	....	....	..	....	....	......	..	C1, D4	....	338	8	M	bo
857CIV	1 12 S	186 50	Do.	....	....	....	..	14.4	....	3 59 S	3	14.4	....	.3512	3	D4	EI3,189.1234†	349	10	M	bo
858CIV	0 55 S	186 45	Do.	17.6	....	8 27 E	3	....	....	....	..	....	....	......	..	C1, D4	....	343	11	M	bo
859CIV	0 17 N	186 11	Jun 25	6.7	....	8 40 E	3	....	....	....	..	....	....	......	..	C1, D4	....	354	7	S	bo
860CIV	0 44 N	186 03	Do.	....	....	....	..	14.8	....	0 25 S	3	14.8	....	.3480	3	D4	EI3,189.1234†	307	7	MS	bo
861CIV	0 52 N	185 58	Do.	17.2	....	8 40 E	2	....	....	....	..	....	....	......	..	C1, D4	....	326	8	M	bo
862CIV	1 42 N	185 05	Jun 26	6.3	....	8 34 E	3	....	....	....	..	....	....	......	..	C1, D4	....	304	7	M	bo
863CIV	2 27 N	184 24	Do.	....	....	....	..	14.5	....	3 00 N	2	14.5	....	.3487	2	D4	EI3,189.1234†	315	8	M	bo
864CIV	2 40 N	184 10	Do.	17.5	....	8 19 E	3	....	....	....	..	....	....	......	..	C1, D4	....	315	10	M	bo
865CIV	3 54 N	183 12	Jun 27	6.4	....	9 08 E	3	....	....	....	..	....	....	......	..	C1, D4	....	326	11	M	bo
866CIV	4 52 N	182 45	Do.	....	....	....	..	14.9	....	7 38 N	2	14.9	....	.3426	2	D4	EI3,189.1234†	335	12	MR	bo
867CIV	5 10 N	182 37	Do.	17.4	....	8 53 E	3	....	....	....	..	....	....	......	..	C1, D4	....	338	13	M	bo
868CIV	6 48 N	181 56	Jun 28	6.2	....	8 43 E	3	....	....	....	..	....	....	......	..	C1, D4	....	326	17	M	bo
869CIV	7 52 N	181 36	Do.	....	....	....	..	14.7	....	13 07 N	2	14.7	....	.3340	2	D4	EI3,189.1234†	335	11	M	bo
870CIV	8 15 N	181 22	Do.	17.6	....	8 57 E	3	....	....	....	..	....	....	......	..	C1, D4	....	321	12	M	bo
871CIV	9 49 N	180 40	Jun 29	6.2	....	9 13 E	3	....	....	....	..	....	....	......	..	C1, D4	....	332	10	M	bo
872CIV	10 50 N	180 14	Do.	....	....	....	..	14.7	....	17 57 N	2	14.7	....	.3238	2	D4	EI3,189.1234†	326	12	M	o
873CIV	11 11 N	179 50	Do.	17.6	....	9 22 E	3	....	....	....	..	....	....	......	..	C1, D4	....	326	12	M	bo
874CIV[1]	12 44 N	179 13	Jul 1	7.9	....	9 07 E	2	....	....	....	..	....	....	......	..	C1	....	349	13	MR	o
875CIV	13 06 N	178 59	Do.	....	....	....	..	15.2	....	21 13 N	3	15.2	....	.3136	3	D4	EI3,189.1234†	315	11	M	bo
876CIV	13 17 N	178 52	Do.	17.1	....	8 25 E	3	....	....	....	..	....	....	......	..	C1, D4	....	338	14	M	bo
877CIV	14 29 N	177 36	Jul 2	6.2	....	9.08 E	3	....	....	....	..	....	....	......	..	C1, D4	....	304	18	M	bo
878CIV	15 00 N	176 36	Do.	....	....	....	..	14.4	....	23 41 N	3	14.6	....	.3127	3	D4	EI3,189.1234†	281	17	M	bo
879CIV	15 03 N	176 23	Do.	16.6	....	9 00 E	2	....	....	....	..	....	....	......	..	C1, D4	....	225	10	M	bo
880CIV	15 35 N	174 39	Jul 3	8.3	....	9 01 E	2	....	....	....	..	....	....	......	..	C1	....	281	10	M	o
881CIV	15 43 N	174 17	Do.	....	....	....	..	14.9	....	24 21 N	3	14.9	....	.3108	3	D4	189.1234†	281	16	M	or
882CIV	16 04 N	172 48	Jul 4	6.6	....	8 32 E	3	....	....	....	..	....	....	......	..	C1, D4	....	281	11	M	bo
883CIV	16 30 N	171 51	Do.	....	....	....	..	14.8	....	24 37 N	3	14.8	....	.3110	3	D4	EI3,189.1234†	292	7	M	o
884CIV	16 36 N	171 37	Do.	17.3	....	8 07 E	3	....	....	....	..	....	....	......	..	C1, D4	....	236	11	M	bo
885CIV	17 06 N	170 37	Jul 5	6.5	....	7 58 E	3	....	....	....	..	....	....	......	..	C1, D4	....	292	8	M	bo
886CIV	17 28 N	169 53	Do.	....	....	....	..	14.4	....	25 37 N	3	14.4	....	.3093	3	D4	EI3,189.1234†	287	12	M	bo
887CIV	17 37 N	169 32	Do.	17.5	....	7 32 E	3	....	....	....	..	....	....	......	..	C1, D4	....	298	10	M	bc
888CIV	18 06 N	167 59	Jul 6	6.5	....	7 16 E	3	....	....	....	..	....	....	......	..	C1, D4	....	287	12	M	bc
889CIV	18 24 N	167 14	Do.	....	....	....	..	15.1	....	25 59 N	3	15.1	....	.3109	3	D4	EI3,189.1234†	292	15	M	bo
890CIV	18 33 N	167 01	Do.	17.5	....	6 43 E	3	....	....	....	..	....	....	......	..	C1, D4	....	292	9	S	bo
891CIV	19 12 N	165 46	Jul 7	6.6	....	6 29 E	3	....	....	....	..	....	....	......	..	C1, D4	....	292	15	M	bo
892CIV	19 32 N	165 03	Do.	....	....	....	..	14.3	....	26 02 N	3	14.3	....	.3132	3	D4	189.1234†	292	15	M	bo
893CIV	19 41 N	164 41	Do.	17.6	....	6 42 E	3	....	....	....	..	....	....	......	..	C1, D4	....	304	9	S	bo

[1] June 30 omitted on crossing the 180th meridian.

CRUISE IV, PACIFIC OCEAN, 1916–1917—*Continued*.

	° ′	° ′	1916	h	h	° ′		h	h	° ′		h	h	c.g.s.				°	°		
894CIV	20 17 N	163 30	Jul 8	6.5	....	6 00 E	3	....	....	....	..	....	....	......	..	C1, D4	....	292	8	M	bo
895CIV	20 22 N	162 50	Do.	....	....	....	..	14.2	....	27 35 N	3	14.2	....	0.3098	3	D4	189.1234†	270	12	MS	bo
896CIV	20 24 N	162 36	Do.	17.9	....	5 11 E	3	....	....	....	..	....	....	......	..	C1, D4	....	270	7	S	bo
897CIV	20 31 N	161 44	Jul 9	6.0	....	4 52 E	3	....	....	....	..	....	....	......	..	C1, D4	....	270	10	M	bo
898CIV	20 24 N	160 58	Do.	....	....	....	..	14.4	....	28 17 N	3	14.4	....	.3072	3	D4	EI3,189.1234†	248	19	M	bo
899CIV	20 22 N	160 43	Do.	17.9	....	4 49 E	3	....	....	....	..	....	....	......	..	C1, D4	....	248	9	S	bo
900CIV	20 07 N	159 56	Jul 10	5.9	....	4 20 E	3	....	....	....	..	....	....	......	..	C1, D4	....	264	10	M	bo
901CIV	19 54 N	159 15	Do.	....	....	....	..	14.4	....	26 26 N	3	14.4	....	.3150	3	D4	EI3,189.1234†	242	10	M	bo
902CIV	19 49 N	158 59	Do.	18.0	....	4 05 E	3	....	....	....	..	....	....	......	..	C1, D4	....	242	8	M	bo
903CIV	19 29 N	158 05	Jul 11	6.4	....	4 05 E	3	....	....	....	..	....	....	......	..	C1, D4	....	236	10	M	bo
904CIV	19 17 N	157 31	Do.	....	....	....	..	14.2	....	25 36 N	3	14.1	....	.3167	3	D4	EI3,189.1234†	236	8	M	bo
905CIV	19 08 N	157 11	Do.	18.1	....	3 41 E	3	....	....	....	..	....	....	......	..	C1, D4	....	236	16	M	bo
906CIV	18 28 N	155 51	Jul 12	6.2	....	3 31 E	3	....	....	....	..	....	....	......	..	C1, D4	....	231	10	M	bo
907CIV	18 04 N	155 02	Do.	....	....	....	..	14.4	....	23 07 N	3	14.4	....	.3250	3	D4	EI3,189.1234†	236	14	M	bo
908CIV	17 55 N	154 44	Do.	17.9	....	3 14 E	3	....	....	....	..	....	....	......	..	C1, D4	....	236	10	M	bo
909CIV	17 20 N	153 29	Jul 13	6.2	....	2 59 E	3	....	....	....	..	....	....	......	..	C1, D4	....	236	15	M	bo
910CIV	16 58 N	152 42	Do.	....	....	....	..	14.2	....	21 27 N	2	14.2	....	.3293	2	D4	EI3,189.1234†	236	17	M	bo
911CIV	16 50 N	152 23	Do.	17.5	....	3 11 E	3	....	....	....	..	....	....	......	..	C1, D4	....	236	22	M	bo
912CIV	16 13 N	151 10	Jul 14	6.2	....	2 40 E	3	....	....	....	..	....	....	......	..	C1, D4	....	231	17	M	bo
913CIV	15 49 N	150 25	Do.	....	....	....	..	14.3	....	18 59 N	2	14.3	....	.3348	2	D4	EI3,189.1234†	236	10	M	bo
914CIV	15 39 N	150 07	Do.	17.2	....	2 29 E	3	....	....	....	..	....	....	......	..	C1, D4	....	236	14	M	bo
915CIV	14 54 N	148 41	Jul 15	7.0	....	2 31 E	2	....	....	....	..	....	....	......	..	C1, D4	....	231	16	M	bo
916CIV	14 38 N	147 54	Do.	....	....	....	..	14.3	....	16 35 N	2	14.3	....	.3408	2	D4	EI3,189.1234†	248	19	M	bo
917CIV	14 32 N	147 32	Do.	17.6	....	2 11 E	3	....	....	....	..	....	....	......	..	C1, D4	....	248	20	M	br
918CIV	14 00 N	145 45	Jul 16	....	....	....	..	14.4	....	15 19 N	3	14.3	....	.3468	3	D4	EI3,189.1234†	242	13	M	r
919CIV	13 54 N	145 38	Do.	16.1	....	1 56 E	2	....	....	....	..	....	....	......	..	C1	....	219	8	MS	o
920CIV	13 52 N	145 30	Do.	17.5	....	2 03 E	2	....	....	....	..	....	....	......	..	D4	....	236	11	M	q
921CIV[1]	13 35 N	144 39	Jul 17	8.1	....	2 08 E	1	....	....	....	..	....	....	......	..	C1	....	188	7	S	o
922CIV	14 38 N	144 25	Aug 8	7.4	....	1 17 E	1	....	....	....	..	....	....	......	..	C1	....	326	18	R	or
923CIV	15 24 N	144 14	Do.	....	....	....	..	14.0	....	18 12 N	2	14.0	....	.3437	2	D4	189.1234†	335	27	R	oq
924CIV[2]	16 48 N	144 12	Aug 9	....	....	....	..	14.0	....	20 22 N	1	14.0	....	.3428	1	D4	189.1234†	309	25	R	oq
925CIV[2]	17 24 N	144 30	Aug 10	....	....	....	..	14.0	....	20 53 N	1	14.0	....	.3439	1	D4	189.1234†	335	43	R	oqr
926CIV	17 26 N	144 33	Do.	16.4	....	0 45 E	1	....	....	....	..	....	....	......	..	C1	....	326	23	R	or
927CIV	17 59 N	144 19	Aug 11	....	....	....	..	14.8	....	22 13 N	2	14.8	....	.3414	2	D4	EI3,189.1234†	295	13	R	oqr
928CIV	18 10 N	144 14	Do.	17.1	....	0 45 E	2	....	....	....	..	....	....	......	..	C1	....	338	15	R	qr
929CIV	19 12 N	143 36	Aug 12	8.1	....	0 41 E	1	....	....	....	..	....	....	......	..	C1	....	349	25	R	oq
930CIV	20 14 N	143 35	Do.	....	....	....	..	14.7	....	26 05 N	2	14.7	....	.3373	2	D4	EI3,189.1234†	349	25	R	oq
931CIV	23 03 N	144 27	Aug 13	8.6	....	0 33 W	1	....	....	....	..	....	....	......	..	C1	....	11	22	R	oq
932CIV	23 56 N	144 30	Do.	....	....	....	..	14.8	....	31 59 N	1	14.8	....	.3284	1	D4	189.1234†	0	24	R	oq
933CIV	26 29 N	144 35	Aug 14	7.7	....	1 34 W	1	....	....	....	..	....	....	......	..	C1	....	349	15	R	c
934CIV	26 34 N	144 34	Do.	8.2	....	1 34 W	2	....	....	....	..	....	....	......	..	C1, D4	....	349	34	M	bq
935CIV	27 22 N	144 18	Do.	....	....	....	..	14.6	....	37 37 N	2	14.6	....	.3166	2	D4	189.1234†	349	24	R	bc
936CIV	27 38 N	144 14	Do.	16.9	....	1 58 W	2	....	....	....	..	....	....	......	..	C1, D4	....	349	22	MR	bc
937CIV	29 32 N	144 07	Aug 15	6.4	....	2 44 W	3	....	....	....	..	....	....	......	..	C1, D4	....	349	24	M	bq
938CIV	30 10 N	144 00	Do.	....	....	....	..	15.2	....	41 11 N	2	15.2	....	.3132	2	D4	EI3,189.1234†	Var.	17	MR	o
939CIV	30 14 N	144 06	Do.	17.6	....	2 41 W	3	....	....	....	..	....	....	......	..	C1, D4	....	56	35	M	bc
940CIV	30 14 N	144 27	Aug 16	7.4	....	2 43 W	2	....	....	....	..	....	....	......	..	C1, D4	....	Var,112	10	M	bc
941CIV	30 27 N	144 13	Do.	....	....	....	..	14.0	....	41 54 N	2	14.0	....	.3088	2	D4	189.1234†	338	10	SL	bc
942CIV	30 34 N	144 07	Do.	15.8	....	2 59 W	1	....	....	....	..	....	....	......	..	C1	....	11	12	M	o
943CIV	31 49 N	143 31	Aug 17	9.7	....	3 19 W	1	....	....	....	..	....	....	......	..	C1	....	45	11	M	m
944CIV	32 09 N	143 50	Do.	....	....	....	..	14.4	....	43 35 N	3	14.3	....	.3090	3	D4	EI3,189.1234†	45	12	M	or
945CIV	34 35 N	146 38	Aug 18	....	....	....	..	15.0	....	47 06 N	2	15.0	....	.2931	2	D4	EI3,189.1234†	56	10	R	od
946CIV	36 12 N	149 58	Aug 19	9.3	....	3 14 W	1	....	....	....	..	....	....	......	..	C1	....	68	10	M	c
947CIV	36 40 N	150 54	Do.	....	....	....	..	14.6	....	48 55 N	2	14.6	....	.2862	2	D4	EI3,189.1234†	56	30	R	o
948CIV	38 17 N	153 31	Aug 20	8.3	....	2 43 W	1	....	....	....	..	....	....	......	..	C1	....	56	12	M	d
949CIV	38 25 N	153 43	Do.	9.7	....	2 23 W	1	....	....	....	..	....	....	......	..	C1	....	56	15	M	d
950CIV	38 50 N	154 25	Do.	....	....	....	..	14.5	....	50 53 N	2	14.5	....	.2736	2	D4	EI3,189.1234†	56	10	M	od
951CIV	40 11 N	156 28	Aug 21	8.3	....	1 53 W	1	....	....	....	..	....	....	......	..	C1	....	56	8	MS	c

[1] Between July 17 and August 8 the *Carnegie* was at Guam. [2] Hove to in a gale.

FINAL RESULTS OF OCEAN MAGNETIC OBSERVATIONS ON THE CARNEGIE, 1915–1921—*Continued.*

CRUISE IV, PACIFIC OCEAN, 1916–1917—*Continued.*

Station	Lat.	Long. East of Gr.	Date	Declination L. M. T.		Declination Value	Declination Wt.	Inclination L. M. T.		Inclination Value	Inclination Wt.	Hor. intensity L. M. T.		Hor. intensity Value	Hor. intensity Wt.	Instruments Compass	Instruments Dip Circle	Remarks Course	Remarks Roll	Remarks Sea	Weather
	° ′	° ′	1916	h	h	° ′		h	h	° ′		h	h	c. g. s.				°	°		
952CIV	40 41 N	156 51	Aug 21	....	....	....	..	14.4	....	52 47 N	3	14.3	....	0.2705	3	D4	EI3,189.1234†	45	8	MR	o
953CIV	42 41 N	158 15	Aug 22	9.3	....	1 43 W	2	....	....	....	..	....	....	......	..	C1	....	45	10	M	o
954CIV	43 03 N	158 34	Do.	....	....	....	..	14.4	....	54 58 N	2	14.4	....	.2637	2	D4	EI3,189.1234†	34	12	M	o
955CIV	43 13 N	158 40	Do.	16.8	....	1 27 W	3	....	....	....	..	....	....	......	..	C1, D4	....	34	12	M	bc
956CIV	44 24 N	158 59	Aug 23	5.4	....	1 31 W	3	....	....	....	..	....	....	......	..	C1, D4	....	11	12	M	bc
957CIV	45 10 N	159 26	Do.	....	....	....	..	14.4	....	57 07 N	3	14.4	....	.2541	3	D4	EI3,189.1234†	22	11	M	bc
958CIV	45 21 N	159 32	Do.	16.4	....	1 43 W	2	....	....	....	..	....	....	......	..	C1	....	22	8	S	bc
959CIV	46 20 N	160 12	Aug 24	6.6	....	1 19 W	2	....	....	....	..	....	....	......	..	C1	....	68	11	S	bc
960CIV	46 27 N	160 38	Do.	....	....	....	..	14.1	....	58 18 N	3	14.1	...	.2492	3	D4	189.1234†	79	7	MS	oc
961CIV	46 54 N	162 58	Aug 25	9.9	....	0 32 W	2	....	....	....	..	....	....	......	..	C1	....	79	8	MS	m
962CIV	46 57 N	163 19	Do.	....	....	....	..	14.6	....	58 38 N	3	14.6	....	.2462	3	D4	EI3,189.1234†	79	14	M	m
963CIV	46 57 N	163 27	Do.	16.0	....	0 06 W	2	....	....	....	..	....	....	......	..	C1	....	45	8	S	m
964CIV[1]	47 05 N	165 22	Aug 26	....	....	....	..	7.8 to 15.8		58 47 N	3	7.8 to 15.8		.2447	3	D4	189.1234†	Swing	9	S	om
965CIV	47 03 N	165 21	Do.	14.7	....	0 20 E	1	....	....	....	..	....	....	......	..	C1	....	90	8	S	m
966CIV	47 14 N	166 54	Aug 27	5.5	....	1 44 E	3	....	....	....	..	....	....	......	..	C1, D4	....	84	9	S	bc
967CIV[1]	47 15 N	167 13	Do.	8.1 to 8.8		1 46 E	3	....	....	....	..	....	....	......	..	C1, D4	....	Swing	12	S	bc
968CIV	47 18 N	167 49	Do.	....	....	....	..	13.8	....	58 59 N	3	13.8	....	.2419	3	D4	189.1234†	79	9	M	c
969CIV	47 20 N	168 10	Do.	16.3	....	2 16 E	3	....	....	....	..	....	....	......	..	C1, D4	....	68	10	S	c
970CIV	47 25 N	169 02	Aug 28	5.8	....	1 50 E	3	....	....	....	..	....	....	......	..	C1, D4	....	68	10	S	bc
971CIV	47 26 N	169 24	Do.	....	....	....	..	13.9	....	58 55 N	3	13.9	....	.2428	3	D4	189.1234†	79	6	MS	bc
972CIV	47 28 N	169 40	Do.	16.2	....	3 21 E	3	....	....	....	..	....	....	......	..	C1, D4	....	45	12	S	bc
973CIV	47 42 N	171 42	Aug 29	....	....	....	..	14.6	....	59 41 N	3	14.6	....	.2391	3	D4	EI3,189.1234†	73	6	M	od
974CIV	47 46 N	172 03	Do.	17.2	....	4 03 E	1	....	....	....	..	....	....	......	..	C1	....	73	7	S	r
975CIV	48 09 N	174 24	Aug 30	7.8	....	5 22 E	1	....	....	....	..	....	....	......	..	C1	....	34	10	M	o
976CIV	48 26 N	176 02	Do.	....	....	....	..	15.0	....	60 13 N	2	15.0	....	.2343	2	D4	EI3,189.1234†	73	16	R	om
977CIV[2]	49 00 N	180 23	Do.	14.3	....	8 30 E	1	....	....	....	..	....	....	......	..	C1	....	62	21	M	f
978CIV	49 01 N	180 26	Do.	....	....	....	..	14.8	....	60 55 N	2	14.6	....	.2326	2	D4	EI3,189.1234†	62	21	M	of
979CIV	49 32 N	182 34	Aug 31	....	....	....	..	14.9	....	61 47 N	3	14.9	....	.2276	3	D4	EI3,189.1234†	62	12	M	bc
980CIV	49 34 N	182 47	Do.	17.1	....	10 08 E	3	....	....	....	..	....	....	......	..	C1, D4	....	62	20	M	bc
981CIV	49 56 N	184 29	Sep 1	....	....	....	..	14.2	....	62 32 N	3	14.2	....	.2248	3	D4	EI3,189.1234†	56	10	M	o
982CIV	49 58 N	184 37	Do.	15.7	....	11 05 E	2	....	....	....	..	....	....	......	..	C1	....	68	8	S	c
983CIV	50 46 N	186 56	Sep 2	9.2	....	12 07 E	1	....	....	....	..	....	....	......	..	C1	....	53	8	M	r
984CIV	51 06 N	188 04	Do.	....	....	....	..	14.6	....	63 23 N	2	14.6	....	.2213	2	D4	EI3,189.1234†	68	11	MR	omr
985CIV	51 22 N	191 04	Sep 3	7.0	....	14 20 E	2	....	....	....	..	....	....	......	..	C1, D4	....	101	26	R	oq
986CIV	51 35 N	192 29	Do.	....	....	....	..	14.3	....	64 37 N	2	14.3	....	.2162	2	D4	EI3,189.1234†	62	28	R	oc
987CIV	51 38 N	192 53	Do.	16.3	....	15 25 E	3	....	....	....	..	....	....	......	..	C1, D4	....	51	14	MR	bc
988CIV	51 55 N	195 34	Sep 4	6.6	....	16 32 E	3	....	....	....	..	....	....	......	..	C1, D4	....	56	11	M	bc
989CIV	51 58 N	196 21	Do.	....	....	....	..	14.8	....	65 59 N	3	14.8	....	.2058	3	D4	EI3,189.1234†	62	16	M	o
990CIV	52 28 N	198 39	Sep 5	8.4	....	17 53 E	2	....	....	....	..	....	....	......	..	C1	....	34	8	M	o
991CIV	52 44 N	199 56	Do.	....	....	....	..	14.3	....	66 32 N	3	14.3	....	.2064	3	D4	EI3,189.1234†	51	6	M	o
992CIV	52 47 N	200 14	Do.	15.7	....	18 41 E	2	....	....	....	..	....	....	......	..	C1, D4	....	79	9	M	bc
993CIV	53 22 N	203 31	Sep 6	8.4	....	20 25 E	2	....	....	....	..	....	....	......	..	C1	....	34	20	M	o
994CIV	53 12 N	204 49	Do.	....	....	....	..	14.6	....	67 34 N	3	14.6	....	.2012	3	D4	189.1234†	79	12	M	o
995CIV	52 57 N	208 10	Sep 7	9.2	....	21 55 E	1	....	....	....	..	....	....	......	..	C1	....	34	18	M	c
996CIV	52 53 N	208 50	Do.	....	....	....	..	14.2	....	68 14 N	3	14.2	....	.1987	3	D4	EI3,189.1234†	101	6	M	o
997CIV	51 33 N	212 48	Sep 8	....	....	....	..	14.5	....	68 08 N	2	14.4	....	.2008	2	D4	EI3,189.1234†	118	17	R	or
998CIV	51 16 N	213 14	Do.	17.1	....	22 13 E	2	....	....	....	..	....	....	......	..	C1	....	118	16	M	f
999CIV	49 49 N	215 28	Sep 9	9.1	....	23 19 E	2	....	....	....	..	....	....	......	..	C1	....	68	10	M	f

[1] Swinging ship at sea. [2] August 30 repeated on crossing 180th meridian.

CRUISE IV, PACIFIC OCEAN, 1916–1917—*Continued.*

	° ′	° ′	1916	h	h	° ′		h	h	° ′		h	h	c.g.s.				°	°		
1000CIV	49 16 N	216 13	Sep 9	....	....	....	..	14.6	....	66 59 N	2	14.7	....	0.2104	2	D4	EI3,189.1234†	118	9	M	o
1001CIV	47 42 N	218 15	Sep 10	6.8	....	22 43 E	2	....	....	....	..	....	....	......	..	C1	....	124	10	M	f
1002CIV	46 59 N	218 59	Do.	....	....	....	..	14.5	....	65 47 N	3	14.5	....	.2178	3	D4	EI3,189.1234†	124	8	M	f
1003CIV	46 49 N	219 09	Do.	15.9	....	22 28 E	2	....	....	....	..	....	....	......	..	C1	....	124	8	M	m
1004CIV	45 37 N	220 28	Sep 11	7.8	....	21 53 E	3	....	....	....	..	....	....	......	..	C1, D4	....	124	7	M	f
1005CIV	45 29 N	220 37	Do.	....	....	....	..	14.4	....	64 59 N	3	14.4	....	.2236	3	D4	189.1234†	135	10	M	of
1006CIV	45 26 N	220 39	Do.	15.8	....	21 18 E	3	....	....	....	..	....	....	......	..	C1, D4	....	135	8	S	o
1007CIV	43 44 N	221 35	Sep 12	8.4	....	20 55 E	2	....	....	....	..	....	....	......	..	C1	....	141	6	S	o
1008CIV	43 07 N	221 46	Do.	....	....	....	..	14.3	....	63 36 N	3	14.3	....	.2326	3	D4	EI3,189.1234†	146	10	M	o
1009CIV	42 26 N	221 49	Do.	17.9	....	20 07 E	2	....	....	....	..	....	....	......	..	C1	....	158	8	M	bc
1010CIV	41 31 N	221 43	Sep 13	....	....	....	..	14.1	....	62 02 N	2	14.1	....	.2404	2	D4	EI3,189.1234†	338	15	M	o
1011CIV	41 42 N	221 43	Do.	15.7	....	20 11 E	2	....	....	....	..	....	....	......	..	C1	....	338	10	M	o
1012CIV	40 54 N	221 45	Sep 14	....	....	....	..	14.4	....	61 30 N	3	14.4	....	.2415	3	D4	EI3,189.1234†	135	11	ML	obc
1013CIV	40 51 N	221 46	Do.	15.8	....	19 42 E	2	....	....	....	..	....	....	......	..	C1	....	158	14	M	o
1014CIV	40 48 N	221 54	Sep 15	9.7	....	19 55 E	1	....	....	....	..	....	....	......	..	C1	....	73	10	M	o
1015CIV	40 48 N	222 03	Do.	....	....	....	..	14.1	....	61 37 N	3	14.1	....	.2422	3	D4	EI3,189.1234†	79	9	M	o
1016CIV	40 47 N	222 27	Do.	17.8	....	19 29 E	3	....	....	....	..	....	....	......	..	C1, D4	....	90	7	S	bc
1017CIV	40 41 N	224 04	Sep 16	6.1	....	19 46 E	3	....	....	....	..	....	....	......	..	C1, D4	....	90	6	M	bc
1018CIV	40 39 N	225 18	Do.	....	....	....	..	14.4	....	62 10 N	3	14.3	....	.2413	3	D4	EI3,189.1234†	76	5	M	bc
1019CIV	40 38 N	225 38	Do.	16.3	....	19 14 E	2	....	....	....	..	....	....	......	..	C1	....	79	4	S	o
1020CIV	40 23 N	227 51	Sep 17	5.8	....	19 50 E	2	....	....	....	..	....	....	......	..	C1	....	90	5	S	o
1021CIV	40 03 N	229 07	Do.	....	....	....	..	14.3	....	62 31 N	3	14.3	....	.2427	3	D4	EI3,189.1234†	93	4	M	od
1022CIV	39 56 N	229 27	Do.	18.0	....	19 36 E	3	....	....	....	..	....	....	......	..	C1	....	96	5	S	o
1023CIV	39 41 N	230 05	Sep 18	7.5	....	19 32 E	2	....	....	....	..	....	....	......	..	C1	....	107	10	M	o
1024CIV	39 24 N	231 14	Do.	....	....	....	..	14.2	....	62 14 N	2	14.2	....	.2446	2	D4	EI3,189.1234†	84	9	M	o
1025CIV	38 34 N	234 24	Sep 19	....	....	....	..	14.2	....	62 04 N	2	14.2	....	.2484	3	D4	EI3,189.1234†	79	16	M	o
1026CIV	38 16 N	235 33	Sep 20	....	....	....	..	13.6	....	62 22 N	2	13.6	....	.2470	2	D4	....	79,45	10	MS	om
1027CIV[1]	37 46 N	237 25	Sep 21	9.7	....	18 47 E	1	....	....	....	..	....	....	......	..	C1	....	51	2	S	b
1028CIV[2]	37 50 N	237 37	Sep 25	7.6 to 9.6		18 16 E	3	....	....	....	..	....	....	......	..	C1, D4	....	Swing	2	S	bc
1028aCIV[2]	37 51 N	237 36	Do.	15.4 to 17.6		18 14 E	3	9.8 to 14.2		62 07 N	3	9.8 to 14.2		.2496	3	C1, D4	189.1234†	Swing	2	S	bc
1029CIV	36 06 N	236 41	Nov 2	6.7	....	17 09 E	3	....	....	....	..	....	....	......	..	C1, D5	....	158	9	M	b
1030CIV	35 46 N	236 45	Do.	....	....	....	..	14.7	....	60 06 N	3	14.7	....	.2591	3	C1, D5	189.1234†	158	10	S	b
1031CIV	35 42 N	236 46	Do.	16.4	....	17 08 E	3	....	....	....	..	....	....	......	..	C1, D5	....	158	8	MS	bc
1032CIV	35 22 N	236 14	Nov 3	6.6	....	16 56 E	3	....	....	....	..	....	....	......	..	C1, D5	....	214	8	MS	bc
1033CIV	35 10 N	236 05	Do.	....	....	....	..	14.4	....	59 23 N	3	14.4	....	.2614	3	D5	EI3,189.1234†	152	7	S	bc
1034CIV	34 59 N	236 07	Do.	16.4	....	16 42 E	2	....	....	....	..	....	....	......	..	C1	....	158	7	S	c
1035CIV	34 24 N	236 17	Nov 4	6.8	....	16 13 E	3	....	....	....	..	....	....	......	..	C1, D5	....	146	10	MS	bc
1036CIV	33 56 N	236 36	Do.	....	....	....	..	15.0	....	58 17 N	3	15.1	....	.2678	3	D5	EI3,189.1234†	146	5	MS	c
1037CIV	32 14 N	237 03	Nov 5	7.0	....	15 32 E	2	....	....	....	..	....	....	......	..	C1, D5	....	158	15	ML	bc
1038CIV	31 20 N	237 10	Do.	....	....	....	..	14.4	....	55 56 N	3	14.3	....	.2795	2	D5	EI3,189.1234†	158	25	MRL	bc
1039CIV	31 04 N	237 10	Do.	16.6	....	15 07 E	3	....	....	....	..	....	....	......	..	C1, D5	....	158	25	ML	bc
1040CIV	29 45 N	238 05	Nov 6	6.6	....	14 14 E	3	....	....	....	..	....	....	......	..	C1, D5	....	146	18	ML	bc
1041CIV	28 58 N	238 33	Do.	....	....	....	..	14.9	....	53 35 N	3	14.9	....	.2871	3	D5	EI3,189.1234†	135	14	ML	bc
1042CIV	28 46 N	238 40	Do.	16.7	....	14 23 E	3	....	....	....	..	....	....	......	..	C1, D5	....	135	13	ML	bc
1043CIV	27 16 N	239 43	Nov 7	7.0	....	13 23 E	3	....	....	....	..	....	....	......	..	C1, D5	....	135	12	ML	bc
1044CIV	26 25 N	240 11	Do.	....	....	....	..	14.1	....	50 50 N	2	14.1	....	.2981	2	D5	EI3,189.1234†	135	12	ML	bc
1045CIV	26 12 N	240 18	Do.	15.7	....	12 56 E	3	....	....	....	..	....	....	......	..	C1, D5	....	135	15	M	bc
1046CIV	24 20 N	241 25	Nov 8	6.6	....	12 26 E	3	....	....	....	..	....	....	......	..	C1, D5	....	135	7	M	bc
1047CIV	23 21 N	241 57	Do.	....	....	....	..	14.5	....	47 31 N	3	14.5	....	.3087	3	D5	EI3,189.1234†	135	7	ML	b
1048CIV	23 06 N	242 05	Do.	16.6	....	11 43 E	3	....	....	....	..	....	....	......	..	C1, D5	....	135	7	M	bc
1049CIV	21 19 N	243 08	Nov 9	7.5	....	11 07 E	3	....	....	....	..	....	....	......	..	C1, D5	....	135	8	ML	bc
1050CIV	20 53 N	243 19	Do.	....	....	....	..	14.2	....	44 27 N	3	14.1	....	.3158	3	D5	EI3,189.1234†	135	8	SL	bc
1051CIV	20 47 N	243 22	Do.	17.0	....	10 45 E	3	....	....	....	..	....	....	......	..	C1, D5	....	135	10	ML	b
1052CIV	20 16 N	243 41	Nov 10	7.1	....	10 40 E	3	....	....	....	..	....	....	......	..	C1, D5	....	135	9	ML	c
1053CIV	19 59 N	243 49	Do.	....	....	....	..	14.5	....	42 58 N	3	14.5	....	.3205	3	D5	EI3,189.1234†	135	6	ML	bc
1054CIV	19 55 N	243 50	Do.	16.4	....	10 56 E	3	....	....	....	..	....	....	......	..	C1, D5	....	135	6	S	c
1055CIV	19 36 N	243 51	Nov 11	6.7	....	10 46 E	3	....	....	....	..	....	....	......	..	C1, D5	....	129	7	S	bc
1056CIV	19 28 N	243 54	Do.	....	....	....	..	14.1	....	42 20 N	3	14.1	....	.3213	3	D5	EI3,189.1234†	129	8	S	bc

[1] From September 21 to November 1 the *Carnegie* was at San Francisco. [2] Swinging ship in San Francisco Bay.

FINAL RESULTS OF OCEAN MAGNETIC OBSERVATIONS ON THE CARNEGIE, 1915–1921—*Continued.*

CRUISE IV, PACIFIC OCEAN, 1916–1917—*Continued.*

Station	Lat.	Long. East of Gr.	Date	Declination L. M. T.		Declination Value	Wt.	Inclination L. M. T.		Inclination Value	Wt.	Hor. intensity L. M. T.		Hor. intensity Value	Wt.	Instruments Compass	Instruments Dip Circle	Remarks Course	Roll	Sea	Weather
	° ′	° ′	*1916*	h	h	° ′		h	h	° ′		h	h	c. g. s.				°	°		
1057CIV	19 26 N	243 55	Nov 11	15.6	....	10 43 E	3	....	....	....	..	....	....	......	..	C1, D5	....	129	4	S	bc
1058CIV	19 00 N	244 15	Nov 12	6.4	....	10 25 E	3	....	....	....	..	....	....	......	..	C1, D5	....	135	5	S	bc
1059CIV	18 31 N	244 26	Do.	....	....	....	..	14.2	....	41 06 N	3	14.2	....	0.3243	3	D5	EI3,189.1234†	163	12	MS	bc
1060CIV	18 23 N	244 26	Do.	16.0	....	10 10 E	3	....	....	....	..	....	....	......	..	C1, D5	....	163	9	MS	bc
1061CIV	17 02 N	244 38	Nov 13	8.6	....	10 13 E	2	....	....	....	..	....	....	......	..	C1	....	197	7	S	o
1062CIV	16 33 N	244 39	Do.	....	....	....	..	14.1	....	38 04 N	3	14.1	....	.3299	3	D5	EI3,189.1234†	163	16	ML	o
1063CIV	16 22 N	244 40	Do.	16.0	....	9 53 E	2	....	....	....	..	....	....	......	..	C1, D5	....	163	11	SL	o
1064CIV	14 47 N	244 56	Nov 14	....	....	....	..	14.5	....	35 08 N	3	14.5	....	.3339	3	D5	EI3,189.1234†	169	15	MS	bc
1065CIV	14 46 N	244 56	Do.	14.5	....	9 34 E	2	....	....	....	..	....	....	......	..	C1	....	169	15	M	o
1066CIV	14 39 N	244 56	Do.	16.8	....	9 35 E	3	....	....	....	..	....	....	......	..	C1, D5	....	169	16	ML	bc
1067CIV	14 17 N	244 56	Nov 15	7.4	....	9 38 E	3	....	....	....	..	....	....	......	..	C1, D5	....	169	13	MS	bc
1068CIV	14 10 N	244 56	Do.	....	....	....	..	13.7	....	34 13 N	2	13.7	....	.3349	3	D5	189.1234†	169	10	ML	bc
1069CIV	14 01 N	244 57	Do.	16.8	....	9 32 E	3	....	....	....	..	....	....	......	..	C1, D5	....	169	8	SL	bc
1070CIV	12 54 N	244 52	Nov 16	6.4	....	9 19 E	3	....	....	....	..	....	....	......	..	C1, D5	....	169	7	SL	bc
1071CIV	12 02 N	245 01	Do.	....	....	....	..	14.6	....	30 38 N	3	14.4	....	.3376	2	D5	EI3,189.1234†	146	5	MS	bc
1072CIV	11 45 N	245 06	Do.	16.7	....	9 14 E	3	....	....	....	..	....	....	......	..	C1, D5	....	146	5	ML	bc
1073CIV	10 09 N	245 57	Nov 17	6.4	....	9 00 E	3	....	....	....	..	....	....	......	..	C1, D5	....	135	13	ML	bc
1074CIV	9 21 N	246 31	Do.	....	....	....	..	14.2	....	26 03 N	2	14.2	....	.3399	2	D5	EI3,189.1234†	141	13	MRC	q
1075CIV	9 10 N	246 37	Do.	16.2	....	8 46 E	3	....	....	....	..	....	....	......	..	C1, D5	....	135	14	MRC	q
1076CIV	8 48 N	246 39	Nov 18	6.3	....	8 53 E	2	....	....	....	..	....	....	......	..	C1	....	112	23	C	o
1077CIV	8 54 N	246 26	Do.	....	....	....	..	15.2	....	25 16 N	2	15.2	....	.3410	2	D5	EI3,189.1234†	118	19	MRC	bc
1078CIV	8 54 N	246 30	Do.	17.5	....	8 53 E	2	....	....	....	..	....	....	......	..	C1	....	79	25	MRC	o
1079CIV	8 53 N	247 22	Nov 19	....	....	....	..	13.7	....	25 31 N	2	13.7	....	.3406	2	D5	EI3,189.1234†	112	16	ML	o
1080CIV	8 48 N	247 30	Do.	15.6	....	8 53 E	2	....	....	....	..	....	....	......	..	C1	....	112	18	MR	o
1081CIV	8 00 N	248 28	Nov 20	9.2	....	8 50 E	1	....	....	....	..	....	....	......	..	C1	....	68	20	M	r
1082CIV	7 46 N	248 39	Do.	....	....	....	..	14.8	....	23 40 N	2	14.7	....	.3413	2	D5	EI3,189.1234†	141	9	M	bc
1083CIV	7 42 N	248 43	Do.	16.5	....	8 50 E	3	....	....	....	..	....	....	......	..	C1, D5	....	135	6	ML	bc
1084CIV	7 42 N	248 55	Nov 21	7.2	....	8 45 E	2	....	....	....	..	....	....	......	..	C1	....	56	7	M	o
1085CIV	7 34 N	249 46	Do.	....	....	....	..	14.5	....	23 35 N	2	14.5	....	.3414	2	D5	EI3,189.1234†	90	9	MRL	o
1086CIV	7 32 N	250 22	Nov 22	8.0	....	8 55 E	2	....	....	....	..	....	....	......	..	C1, D5	....	248	10	ML	bc
1087CIV	7 28 N	250 46	Do.	....	....	....	..	14.8	....	23 33 N	2	14.8	....	.3427	3	D5	EI3,189.1234†	101	10	MS	bc
1088CIV	7 15 N	251 05	Nov 23	7.9	....	8 53 E	2	....	....	....	..	....	....	......	..	C1, D5	....	112	12	MS	co
1089CIV	7 10 N	251 15	Do.	....	....	....	..	14.6	....	23 12 N	3	14.5	....	.3418	2	D5	EI3,189.1234†	Var. 180–90	7	S	r
1090CIV	7 06 N	250 36	Nov 24	6.9	....	9 01 E	2	....	....	....	..	....	....	......	..	C1	....	68	25	MR	o
1091CIV	7 00 N	251 16	Do.	....	....	....	..	14.8	....	23 04 N	2	14.8	....	.3413	2	D5	EI3,189.1234†	96	23	M	od
1092CIV	6 52 N	252 49	Nov 25	8.6	....	8 43 E	1	....	....	....	..	....	....	......	..	C1	....	62	14	M	o
1093CIV	6 52 N	253 13	Do.	....	....	....	..	14.5	....	23 03 N	3	14.5	....	.3431	3	D5	EI3,189.1234†	90	10	MSL	od
1094CIV	6 21 N	253 31	Nov 26	8.4	....	9 04 E	1	....	....	....	..	....	....	......	..	C1	....	202	16	M	m
1095CIV	6 11 N	253 15	Do.	....	....	....	..	15.0	....	21 49 N	3	14.9	....	.3418	3	D5	EI3,189.1234†	262, 135,90	14	MS	om
1096CIV	5 37 N	252 19	Nov 27	6.5	....	8 58 E	3	....	....	....	..	....	....	......	..	C1, D5	....	236	12	MRL	bc
1097CIV	5 22 N	251 41	Do.	....	....	....	..	13.6	....	19 52 N	2	13.6	....	.3428	2	D5	189.1234†	242	15	ML	bc
1098CIV	5 07 N	249 52	Nov 28	6.6	....	8 49 E	3	....	....	....	..	....	....	......	..	C1, D5	....	259	11	M	bc
1099CIV	5 04 N	249 06	Do.	....	....	....	..	15.0	....	18 42 N	3	14.9	....	.3424	3	D5	EI3,189.1234†	248	10	MS	o
1100CIV	4 56 N	248 27	Do.	21.7	....	8 40 E	2	....	....	....	..	....	....	......	..	C1	....	231	7	M	b
1101CIV	4 28 N	247 37	Nov 29	6.6	....	8 46 E	3	....	....	....	..	....	....	......	..	C1, D5	....	214	16	ML	bc
1102CIV	3 52 N	246 46	Do.	....	....	....	..	14.6	....	15 58 N	2	14.6	....	.3404	2	D5	EI3,189.1234†	225	16	ML	bc
1103CIV	3 43 N	246 30	Do.	6.6	....	8 46 E	2	....	....	....	..	....	....	......	..	C1	....	225	10	M	o

CRUISE IV, PACIFIC OCEAN, 1916–1917—*Continued.*

	° ′	° ′	*1916*	*h*	*h*	° ′		*h*	*h*	° ′		*h*	*h*	*c. g. s.*				°	°		
1104CIV	2 25 N	244 35	Nov 30	6.1	....	8 26 E	3	....	....	....	..	....	....	......	..	C1, D5	....	225	11	MR	bc
1105CIV	1 40 N	243 19	Do.	....	....	....	..	13.8	....	10 48 N	2	13.8	....	0.3394	2	D5	189.1234†	205	9	M	b
1106CIV	1 22 N	242 56	Do.	16.8	....	8 36 E	3	....	....	....	..	....	....	......	..	C1, D5	....	208	8	MS	bc
1107CIV	0 06 N	241 39	Dec 1	6.8	....	8 25 E	3	....	....	....	..	....	....	......	..	C1, D5	....	214	7	MS	bc
1108CIV	0 27 S	241 24	Do.	....	....	....	..	14.3	....	6 18 N	3	14.3	....	.3380	3	D5	EI3,189.1234†	180	6	SL	bc
1109CIV	0 42 S	241 16	Do.	17.8	....	8 31 E	3	....	....	....	..	....	....	......	..	C1, D5	....	180	6	MSL	bc
1110CIV	1 19 S	240 53	Dec 2	6.1	....	8 22 E	3	....	....	....	..	....	....	......	..	C1, D5	....	202,158	12	MSL	bc
1111CIV	1 29 S	240 41	Do.	....	....	....	..	14.6	....	3 56 N	3	14.5	....	.3379	3	D5	EI3,189.1234†	180	8	MS	b
1112CIV	1 40 S	240 36	Do.	17.5	....	8 28 E	3	....	....	....	..	....	....	......	..	C1, D5	....	180	7	MSL	bc
1113CIV	2 05 S	240 08	Dec 3	6.8	....	8 32 E	3	....	....	....	..	....	....	......	..	C1, D5	....	191	9	MS	bc
1114CIV	2 29 S	239 54	Do.	....	....	....	..	14.3	....	1 52 N	3	14.4	....	.3372	3	D5	EI3,189.1234†	169–180	8	MSL	bc
1115CIV	2 44 S	239 48	Do.	17.0	....	8 31 E	3	....	....	....	..	....	....	......	..	C1, D5	....	180	10	MSL	bc
1116CIV	3 55 S	239 16	Dec 4	6.2	....	8 29 E	3	....	....	....	..	....	....	......	..	C1, D5	....	180	10	MSL	bc
1117CIV	4 41 S	238 55	Do.	....	....	....	..	14.6	....	2 44 S	3	14.6	....	.3347	2	D5	EI3,189.1234†	208	10	MSL	bc
1118CIV	4 57 S	238 43	Do.	17.3	....	8 43 E	3	....	....	....	..	....	....	......	..	C1, D5	....	214	10	MSL	bc
1119CIV	6 20 S	237 27	Dec 5	6.8	....	8 46 E	3	....	....	....	..	....	....	......	..	C1, D5	....	214	12	M	bc
1120CIV	7 08 S	236 42	Do.	....	....	....	..	14.3	....	7 37 S	3	14.3	....	.3332	3	D5	EI3,189.1234†	202	18	ML	bc
1121CIV	7 25 S	236 26	Do.	17.3	....	8 56 E	3	....	....	....	..	....	....	......	..	C1, D5	....	202	12	M	bc
1122CIV	9 02 S	235 12	Dec 6	6.8	....	8 59 E	3	....	....	....	..	....	....	......	..	C1, D5	....	191	18	M	bc
1123CIV	10 02 S	234 54	Do.	....	....	....	..	14.7	....	13 38 S	3	14.7	....	.3316	2	D5	EI3,189.1234†	177	13	MR	bc
1124CIV	10 21 S	234 48	Do.	17.1	....	9 20 E	3	....	....	....	..	....	....	......	..	C1, D5	....	191	13	M	bc
1125CIV	12 00 S	234 34	Dec 7	6.4	....	9 24 E	2	....	....	....	..	....	....	......	..	C1	....	174	21	MR	c
1126CIV	12 54 S	234 26	Do.	....	....	....	..	14.2	....	19 02 S	3	14.2	....	.3270	2	D5	EI3,189.1234†	169–191	13	MR	bc
1127CIV	13 20 S	234 21	Do.	17.4	....	9 47 E	2	....	....	....	..	....	....	......	..	C1, D5	....	180	20	MR	bc
1128CIV	15 11 S	234 09	Dec 8	6.8	....	9 48 E	2	....	....	....	..	....	....	......	..	C1, D5	....	169	13	MR	bc
1129CIV	16 00 S	234 12	Do.	....	....	....	..	14.8	....	24 35 S	2	14.8	....	.3229	2	D5	EI3,189.1234†	174	27	MR	bcr
1130CIV	16 10 S	234 12	Do.	17.2	....	10 04 E	3	....	....	....	..	....	....	......	..	C1, D5	....	152	15	MR	bc
1131CIV	17 19 S	234 02	Dec 9	6.2	....	10 19 E	3	....	....	....	..	....	....	......	..	C1, D5	....	180	15	M	bc
1132CIV	18 06 S	233 50	Do.	....	....	....	..	14.4	....	27 56 S	3	14.3	....	.3210	2	D5	EI3,189.1234†	180–135	7	M	bcr
1133CIV	18 26 S	233 45	Do.	17.3	....	10 44 E	3	....	....	....	..	....	....	......	..	C1, D5	....	180	14	M	bc
1134CIV	19 51 S	233 24	Dec 10	6.1	....	10 55 E	3	....	....	....	..	....	....	......	..	C1, D5	....	169	11	M	bc
1135CIV	20 26 S	233 15	Do.	....	....	....	..	14.7	....	31 31 S	3	14.7	....	.3180	3	D5	EI3,189.1234†	169	10	MS	bcq
1136CIV	20 38 S	233 14	Do.	17.0	....	11 06 E	3	....	....	....	..	....	....	......	..	C1, D5	....	169	15	M	bc
1137CIV	21 50 S	233 27	Dec 11	6.2	....	11 22 E	3	....	....	....	..	....	....	......	..	C1, D5	....	163	12	M	bc
1138CIV	22 33 S	233 32	Do.	....	....	....	..	14.3	....	34 35 S	3	14.3	....	.3155	3	D5	EI3,189.1234†	146	8	S	bc
1139CIV	22 51 S	233 35	Do.	17.4	....	11 34 E	3	....	....	....	..	....	....	......	..	C1, D5	....	158	6	M	bc
1140CIV	24 14 S	233 56	Dec 12	6.2	....	11 57 E	3	....	....	....	..	....	....	......	..	C1, D5	....	158	8	M	bc
1141CIV	25 05 S	234 11	Do.	....	....	....	..	14.6	....	38 14 S	3	14.6	....	.3112	3	D5	EI3,189.1234†	127	7	S	bc
1142CIV	25 20 S	234 24	Do.	17.6	....	12 32 E	3	....	....	....	..	....	....	......	..	C1, D5	....	124	7	M	bc
1143CIV	26 13 S	235 13	Dec 13	6.3	....	12 28 E	3	....	....	....	..	....	....	......	..	C1, D5	....	124	7	MS	bc
1144CIV	26 36 S	235 42	Do.	....	....	....	..	14.3	....	39 40 S	3	14.3	....	.3081	3	D5	EI3,189.1234†	112	8	MS	c
1145CIV	26 42 S	235 48	Do.	17.0	....	12 14 E	3	....	....	....	..	....	....	......	..	C1, D5	....	112	7	S	bc
1146CIV	27 11 S	236 28	Dec 14	6.2	....	12 47 E	3	....	....	....	..	....	....	......	..	C1, D5	....	112	6	S	bc
1147CIV	27 25 S	236 48	Do.	....	....	....	..	14.4	....	40 50 S	3	14.4	....	.3056	3	D5	EI3,189.1234†	115	12	S	bc
1148CIV	27 28 S	236 53	Do.	17.9	....	12 47 E	3	....	....	....	..	....	....	......	..	C1, D5	....	112	10	S	bc
1149CIV	27 45 S	237 14	Dec 15	6.2	....	13 23 E	3	....	....	....	..	....	....	......	..	C1, D5	....	112	16	ML	b
1150CIV	27 56 S	237 31	Do.	....	....	....	..	14.3	....	41 16 S	3	14.3	....	.3038	2	D5	EI3,189.1234†	115	14	SL	bc
1151CIV	28 01 S	237 37	Do.	18.5	....	13 14 E	3	....	....	....	..	....	....	......	..	C1, D5	....	124	22	ML	bc
1152CIV	28 40 S	238 13	Dec 16	7.0	....	13 35 E	2	....	....	....	..	....	....	......	..	C1, D5	....	124	16	ML	bc
1153CIV	29 06 S	238 43	Do.	....	....	....	..	14.7	....	42 40 S	2	14.7	....	.3012	3	D5	EI3,189.1234†	124	15	SL	bc
1154CIV	29 15 S	238 54	Do.	17.3	....	13 34 E	3	....	....	....	..	....	....	......	..	C1, D5	....	124	14	ML	bc
1155CIV	29 56 S	239 42	Dec 17	5.4	....	13 47 E	3	....	....	....	..	....	....	......	..	C1, D5	....	180,124	13	M	bc
1156CIV	30 31 S	240 42	Do.	....	....	....	..	14.2	....	44 01 S	2	14.2	....	.2987	2	D5	EI3,189.1234	68	11	M	bc
1157CIV	30 32 S	241 16	Do.	17.5	....	14 51 E	3	....	....	....	..	....	....	......	..	C1, D5	....	90	14	M	c
1158CIV	31 35 S	242 18	Dec 18	6.4	....	14 51 E	2	....	....	....	..	....	....	......	..	C1, D5	....	146	20	M	bc
1159CIV	31 45 S	243 06	Do.	....	....	....	..	14.8	....	44 56 S	2	14.8	....	.2964	2	D5	EI3,189.1234†	45	12	M	c
1160CIV	31 39 S	243 24	Do.	16.9	....	14 46 E	1	....	....	....	..	....	....	......	..	C1	....	90	20	M	c
1161CIV	31 42 S	243 37	Do.	18.6	....	15 26 E	2	....	....	....	..	....	....	......	..	C1	....	90	16	M	c
1162CIV	31 59 S	244 43	Dec 19	6.4	....	15 41 E	2	....	....	....	..	....	....	......	..	C1, D5	....	141	18	M	bd

FINAL RESULTS OF OCEAN MAGNETIC OBSERVATIONS ON THE CARNEGIE, 1915–1921—*Continued.*

CRUISE IV, PACIFIC OCEAN, 1916–1917—*Continued.*

Station	Lat.	Long. East of Gr.	Date	Declination L. M. T.		Declination Value	Declination Wt.	Inclination L. M. T.		Inclination Value	Inclination Wt.	Hor. intensity L. M. T.		Hor. intensity Value	Hor. intensity Wt.	Instruments Compass	Instruments Dip Circle	Remarks Course	Remarks Roll	Remarks Sea	Weather
	° ′	° ′	*1916*	h	h	° ′		h	h	° ′		h	h	c. g. s.				°	°		
1163CIV	32 16 S	245 39	Dec 19	....	....	....	..	14.2	....	45 08 S	3	14.2	....	0.2036	3	D5	EI3,189.1234†	135	19	ML	bc
1164CIV	32 24 S	246 00	Do.	18.3	....	15 16 E	2	....	....	....	..	....	....	......	..	C1, D5	....	73	22	M	bc
1165CIV	32 33 S	247 05	Dec 20	6.5	....	15 12 E	3	....	....	....	..	....	....	......	..	C1, D5	....	73	10	M	bc
1166CIV	32 12 S	248 43	Do.	....	....	....	..	14.8	....	44 28 S	2	14.8	....	.2919	2	D5	EI3,189.1234†	45	13	MR	bcq
1167CIV	32 06 S	248 58	Do.	16.5	....	16 06 E	2	....	....	....	..	....	....	......	..	C1	....	45	18	MR	cq
1168CIV	31 18 S	250 29	Dec 21	6.4	....	15 36 E	3	....	....	....	..	....	....	......	..	C1, D5	....	34	8	M	b
1169CIV	30 55 S	251 06	Do.	....	....	....	..	14.4	....	43 12 S	3	14.4	....	.2928	3	D5	EI3,189.1234†	20	6	MS	bc
1170CIV	30 46 S	251 14	Do.	18.6	....	16 52 E	3	....	....	....	..	....	....	......	..	C1, D5	....	0	10	S	bc
1171CIV	30 40 S	251 08	Dec 22	6.2	....	16 26 E	3	....	....	....	..	....	....	......	..	C1, D5	....	349	11	S	b
1172CIV	30 36 S	251 11	Do.	....	....	....	..	14.5	....	41 51 S	3	14.5	....	.2956	3	D5	EI3,189.1234†	107	13	MS	bc
1173CIV	30 42 S	251 20	Do.	18.0	....	15 57 E	3	....	....	....	..	....	....	......	..	C1, D5	....	107	9	S	bc
1174CIV	30 48 S	251 26	Dec 23	6.2	....	15 38 E	3	....	....	....	..	....	....	......	..	C1, D5	....	349	7	S	bc
1175CIV	30 05 S	251 25	Do.	....	....	....	..	14.3	....	41 11 S	3	14.3	....	.2948	3	D5	EI3,189.1234†	338	7	MR	bc
1176CIV	29 42 S	251 24	Do.	17.9	....	15 11 E	3	....	....	....	..	....	....	......	..	C1, D5	....	349	8	MR	bc
1177CIV[1]	27 57 S	251 20	Dec 24	6.2	....	14 30 E	2	....	....	....	..	....	....	......	..	C1, D5	....	326	20	MR	b
			1917																		
1178CIV[2]	27 08 S	250 34	Jan 2	7.5	....	12 36 E	3	....	....	....	..	....	....	......	..	C1, D5	....	326	5	S	bc
1179CIV	26 38 S	250 12	Do.	....	....	....	..	14.8	....	37 37 S	3	14.8	....	.2988	3	D5	EI3,189.1234†	326	7	MS	bc
1180CIV	26 29 S	250 07	Do.	16.6	....	13 34 E	2	....	....	....	..	....	....	......	..	C1, D5	....	338	5	S	bc
1181CIV	25 05 S	249 17	Jan 3	6.2	....	13 02 E	3	....	....	....	..	....	....	......	..	C1, D5	....	332	11	M	bc
1182CIV	23 58 S	248 58	Do.	....	....	....	..	14.4	....	34 32 S	3	14.4	....	.3039	2	D5	EI3,189.1234†	338	12	M	c
1183CIV	23 35 S	248 55	Do.	17.4	....	12 29 E	2	....	....	....	..	....	....	......	..	C1, D5	....	349	12	MR	c
1184CIV	22 07 S	248 45	Jan 4	6.5	....	12 20 E	2	....	....	....	..	....	....	......	..	C1, D5	....	349	16	M	bc
1185CIV	21 05 S	248 52	Do.	....	....	....	..	14.8	....	30 17 S	2	14.8	....	.3060	2	D5	EI3,189.1234†	357	17	M	bc
1186CIV	20 41 S	248 51	Do.	17.6	....	12 21 E	3	....	....	....	..	....	....	......	..	C1, D5	....	349	13	M	bc
1187CIV	18 50 S	248 34	Jan 5	7.3	....	11 18 E	2	....	....	....	..	....	....	......	..	C1	....	349	18	M	bc
1188CIV	17 54 S	248 40	Do.	....	....	....	..	14.5	....	24 59 S	3	14.5	....	.3115	2	D5	EI3,189.1234†	11	16	MR	bc
1189CIV	17 28 S	248 44	Do.	18.1	....	11 01 E	3	....	....	....	..	....	....	......	..	C1, D5	....	354	8	M	c
1190CIV	15 34 S	248 56	Jan 6	8.0	....	10 29 E	2	....	....	....	..	....	....	......	..	C1, D5	....	0	12	M	c
1191CIV	14 45 S	248 51	Do.	....	....	....	..	14.7	....	19 32 S	2	14.7	....	.3175	2	D5	EI3,189.1234†	357	14	M	bcq
1192CIV	14 23 S	248 52	Do.	17.4	....	10 53 E	3	....	....	....	..	....	....	......	..	C1, D5	....	349	12	M	c
1193CIV	12 31 S	248 54	Jan 7	7.9	....	9 58 E	2	....	....	....	..	....	....	......	..	C1	....	11	14	M	c
1194CIV	12 29 S	248 23	Do.	....	....	....	..	14.5	....	15 42 S	3	14.5	....	.3206	3	D5	EI3,189.1234†	259	15	M	bc
1195CIV	12 29 S	248 04	Do.	17.5	....	10 53 E	3	....	....	....	..	....	....	......	..	C1, D5	....	259	8	MS	b
1196CIV	12 30 S	246 37	Jan 8	6.2	....	9 45 E	3	....	....	....	..	....	....	......	..	C1, D5	....	259	10	MS	bc
1197CIV	12 30 S	245 31	Do.	....	....	....	..	14.6	....	16 17 S	3	14.6	....	.3219	3	D5	EI3,189.1234†	259	11	M	b
1198CIV	12 31 S	245 08	Do.	17.5	....	9 58 E	3	....	....	....	..	....	....	......	..	C1, D5	....	259	13	M	bc
1199CIV	12 33 S	243 34	Jan 9	6.6	....	9 40 E	3	....	....	....	..	....	....	......	..	C1, D5	....	259	9	MS	bc
1200CIV	12 34 S	242 38	Do.	....	....	....	..	14.3	....	17 02 S	3	14.3	....	.3222	3	D5	EI3,189.1234†	259	17	MS	bc
1201CIV	12 35 S	242 13	Do.	17.4	....	9 43 E	3	....	....	....	..	....	....	......	..	C1, D5	....	259	14	MS	bc
1202CIV	12 36 S	240 26	Jan 10	6.7	....	9 37 E	3	....	....	....	..	....	....	......	..	C1, D5	....	259	12	MS	bc
1203CIV	12 36 S	239 24	Do.	....	....	....	..	14.5	....	17 46 S	2	14.5	....	.3248	3	D5	EI3,189.1234†	259	16	MS	bc
1204CIV	12 38 S	239 05	Do.	16.9	....	9 29 E	2	....	....	....	..	....	....	......	..	C1	....	259	16	M	c
1205CIV	12 40 S	237 23	Jan 11	7.4	....	9 22 E	2	....	....	....	..	....	....	......	..	C1, D5	....	259	18	M	c
1206CIV	12 55 S	236 27	Do.	....	....	....	..	14.7	....	18 26 S	2	14.7	....	.3249	2	D5	EI3,189.1234†	214	20	MR	bc
1207CIV	13 10 S	236 12	Do.	17.2	....	10 00 E	2	....	....	....	..	....	....	......	..	C1, D5	....	214	19	M	bc
1208CIV	14 06 S	234 54	Jan 12	6.8	....	9 55 E	3	....	....	....	..	....	....	......	..	C1, D5	....	214	13	M	bc
1209CIV	14 40 S	234 16	Do.	....	....	....	..	14.6	....	22 01 S	2	14.6	....	.3246	2	D5	EI3,189.1234†	214	20	M	bc
1210CIV	14 53 S	234 03	Do.	18.2	....	10 13 E	2	....	....	....	..	....	....	......	..	C1	....	214	15	M	bc

[1] From December 24, 1916, to January 2, 1917, the *Carnegie* was at Easter Island.

[2] Local disturbance in Cook Bay, Easter Island.

CRUISE IV, PACIFIC OCEAN, 1916–1917—*Continued.*

	° ′	° ′	1917	h	h	° ′		h	h	° ′		h	h	c. g. s.				°	°		
1211CIV	15 48 S	233 06	Jan 13	6.2	....	10 03 E	3	....	....	....	..	....	....	......	..	C1, D5	....	214	18	M	bc
1212CIV	16 08 S	232 38	Do.	....	....	....	..	14.4	....	24 56 S	3	14.4	....	0.3234	3	D5	EI3,189.1234†	214	22	SL	bc
1213CIV	16 21 S	232 23	Do.	18.4	....	10 16 E	2	....	....	....	..	....	....	......	..	C1	....	214	10	MS	c
1214CIV	16 59 S	231 46	Jan 14	7.0	....	10 39 E	3	....	....	....	..	....	....	......	..	C1, D5	....	214	7	S	bc
1215CIV	17 42 S	231 09	Do.	....	....	....	..	14.4	....	27 44 S	3	14.4	....	.3212	3	D5	EI3,189.1234†	214	9	M	bc
1216CIV	19 35 S	230 06	Jan 15	9.4	....	10 49 E	1	....	....	....	..	....	....	......	..	C1	....	270	15	M	d
1217CIV	19 36 S	230 02	Do.	....	....	....	..	14.5	....	30 48 S	2	14.4	....	.3206	2	D5	EI3,189.1234†	225	26	M	c
1218CIV	19 38 S	229 49	Jan 16	7.3	....	10 43 E	2	....	....	....	..	....	....	......	..	C1, D5	....	Var.225	16	M	bc
1219CIV	19 42 S	229 46	Do.	....	....	....	..	14.7	....	31 13 S	2	14.6	....	.3194	2	D5	EI3,189.1234†	Var.194	18	LS	b
1220CIV	19 42 S	229 45	Do.	17.7	....	10 45 E	2	....	....	....	..	....	....	......	..	C1, D5	....	Var.225	20	MSL	bc
1221CIV	19 58 S	229 18	Jan 17	6.6	....	11 13 E	2	....	....	....	..	....	....	......	..	C1	....	225	22	MSL	c
1222CIV	20 18 S	228 54	Do.	....	....	....	..	14.6	....	32 05 S	3	14.6	....	.3194	2	D5	EI3,189.1234†	225	17	MSL	r
1223CIV	21 21 S	227 31	Jan 18	7.7	....	11 31 E	2	....	....	....	..	....	....	......	..	C1, D5	....	219	28	MRL	c
1224CIV	21 48 S	226 48	Do.	....	....	....	..	14.8	....	34 47 S	2	14.7	....	.3200	2	D5	EI3,189.1234†	236	24	MSL	bc
1225CIV	21 55 S	226 29	Do.	17.3	....	11 36 E	2	....	....	....	..	....	....	......	..	C1, D5	....	236	20	ML	bc
1226CIV	22 53 S	225 18	Jan 19	6.5	....	11 45 E	3	....	....	....	..	....	....	......	..	C1, D5	....	191	11	ML	bc
1227CIV	23 55 S	224 58	Do.	....	....	....	..	14.5	....	37 53 S	2	14.5	....	.3154	2	D5	EI3,189.1234†	180	11	ML	bc
1228CIV	24 24 S	224 51	Do.	17.8	....	11 58 E	3	....	....	....	..	....	....	......	..	C1, D5	....	180	12	ML	bc
1229CIV	26 08 S	223 56	Jan 20	6.4	....	12 23 E	3	....	....	....	..	....	....	......	..	C1, D5	....	202	8	M	bc
1230CIV	27 01 S	223 14	Do.	....	....	....	..	14.7	....	42 44 S	3	14.7	....	.3100	2	D5	EI3,189.1234†	197	9	M	bc
1231CIV	27 22 S	223 01	Do.	17.7	....	12 50 E	3	....	....	....	..	....	....	......	..	C1, D5	....	191	8	M	bc
1232CIV	28 53 S	221 43	Jan 21	6.8	....	12 51 E	3	....	....	....	..	....	....	......	..	C1, D5	....	214	10	M	bc
1233CIV	29 53 S	220 53	Do.	....	....	....	..	14.4	....	46 28 S	2	14.4	....	.3046	2	D5	EI3,189.1234†	191	9	M	bc
1234CIV	30 20 S	220 37	Do.	18.0	....	13 37 E	3	....	....	....	..	....	....	......	..	C1, D5	....	180	9	M	bc
1235CIV	31 54 S	220 29	Jan 22	8.7	....	13 47 E	2	....	....	....	..	....	....	......	..	C1	....	158	10	M	c
1236CIV	32 31 S	220 19	Do.	....	....	....	..	14.8	....	49 35 S	3	14.8	....	.3000	3	D5	EI3,189.1234†	172	11	M	c
1237CIV	35 05 S	219 54	Jan 23	....	....	....	..	14.5	....	52 30 S	3	14.5	....	.2901	3	D5	EI3,189.1234†	191	9	M	c
1238CIV	35 19 S	219 46	Do.	16.3	....	14 42 E	2	....	....	....	..	....	....	......	..	C1	....	191	10	M	c
1239CIV	37 15 S	218 15	Jan 24	8.9	....	14 31 E	1	....	....	....	..	....	....	......	..	C1	....	202	32	R	c
1240CIV[1]	37 22 S	218 00	Do.	....	....	....	..	14.2	....	55 03 S	1	14.2	....	.2832	1	D5	189.1234†	183	26	R	cq
1241CIV[1]	37 31 S	217 16	Jan 25	7.2	....	15 13 E	1	....	....	....	..	....	....	......	..	C1	....	180	25	R	cq
1242CIV[1]	37 37 S	217 06	Do.	....	....	....	..	14.1	....	55 32 S	2	14.1	....	.2808	2	D5	189.1234†	191	25	R	c
1243CIV[1]	37 47 S	216 09	Jan 26	....	....	....	..	14.3	....	55 39 S	1	14.3	....	.2829	1	D5	189.1234†	202	25	R	cq
1244CIV	37 52 S	215 23	Jan 27	7.4	....	15 17 E	1	....	....	....	..	....	....	......	..	C1, D5	....	231	25	MR	c
1245CIV	37 53 S	215 48	Do.	....	....	....	..	14.6	....	55 47 S	2	14.6	....	.2797	2	D5	189.1234†	90	12	R	c
1246CIV	37 54 S	216 06	Do.	17.3	....	15 20 E	1	....	....	....	..	....	....	......	..	C1	....	90	19	MR	c
1247CIV	37 47 S	216 54	Jan 28	6.4	....	15 27 E	3	....	....	....	..	....	....	......	..	C1, D5	....	79	14	M	c
1248CIV	37 45 S	217 38	Do.	....	....	....	..	14.9	....	55 33 S	2	14.9	....	.2820	2	D5	EI3,189.1234†	48	11	M	cd
1249CIV	37 36 S	218 13	Do.	19.1	....	15 24 E	2	....	....	....	..	....	....	......	..	C1	....	68	11	M	c
1250CIV	38 08 S	219 20	Jan 29	5.8	....	15 35 E	2	....	....	....	..	....	....	......	..	C1	....	158	15	M	c
1251CIV	38 29 S	220 32	Do.	....	....	....	..	15.0	....	55 16 S	2	14.9	....	.2813	2	D5	EI3,189.1234†	101	25	R	bc
1252CIV	38 31 S	220 48	Do.	17.7	....	15 48 E	2	....	....	....	..	....	....	......	..	C1	....	90	28	MR	bc
1253CIV	38 34 S	221 37	Jan 30	5.8	....	16 01 E	3	....	....	....	..	....	....	......	..	C1, D5	....	79	20	MSL	bc
1254CIV	38 31 S	221 44	Do.	....	....	....	..	14.9	....	55 34 S	2	14.9	....	.2809	2	D5	EI3,189.1234†	Var.169	15	MSL	bc
1255CIV	38 31 S	221 46	Do.	17.4	....	16 11 E	2	....	....	....	..	....	....	......	..	C1, D5	....	124	22	MRL	bc
1256CIV	38 59 S	222 10	Jan 31	5.6	....	16 04 E	3	....	....	....	..	....	....	......	..	C1, D5	....	146	12	M	bc
1257CIV	39 47 S	222 25	Do.	....	....	....	..	14.5	....	56 53 S	3	14.5	....	.2752	3	D5	EI3,189.1234†	146	10	MSL	bc
1258CIV	40 05 S	222 25	Do.	17.5	....	16 34 E	3	....	....	....	..	....	....	......	..	C1, D5	....	163	9	M	bc
1259CIV	41 21 S	222 11	Feb 1	5.8	....	16 58 E	3	....	....	....	..	....	....	......	..	C1, D5	....	180	5	MS	bc
1260CIV	42 16 S	221 53	Do.	....	....	....	..	15.0	....	59 05 S	2	15.0	....	.2683	2	D5	EI3,189.1234†	183	5	M	bc
1261CIV	42 31 S	221 44	Do.	17.6	....	17 20 E	2	....	....	....	..	....	....	......	..	C1	....	180	6	M	c
1262CIV	43 41 S	221 17	Feb 2	8.1	....	18 00 E	2	....	....	....	..	....	....	......	..	C1	....	219	17	M	c
1263CIV	43 36 S	221 45	Do.	....	....	....	..	14.6	....	60 17 S	2	14.5	....	.2632	2	D5	EI3,189.1234†	68	12	MSL	bc
1264CIV	42 58 S	224 40	Feb 3	6.2	....	17 25 E	3	....	....	....	..	....	....	......	..	C1, D5	....	51	12	ML	c
1265CIV	42 27 S	226 03	Do.	....	....	....	..	14.9	....	58 37 S	2	14.8	....	.2696	2	D5	EI3,189.1234†	56	12	ML	bc
1266CIV	42 21 S	226 17	Do.	16.8	....	17 30 E	3	....	....	....	..	....	....	......	..	C1, D5	....	45	15	ML	c
1267CIV	42 49 S	228 00	Feb 4	8.7	....	18 25 E	1	....	....	....	..	....	....	......	..	C1	....	11	18	M	c
1268CIV	43 24 S	229 04	Do.	....	....	....	..	14.7	....	58 47 S	2	14.6	....	.2699	2	D5	EI3,189.1234	112	27	R	bc

[1] Hove to in a gale.

FINAL RESULTS OF OCEAN MAGNETIC OBSERVATIONS ON THE CARNEGIE, 1915–1921—*Continued.*

CRUISE IV, PACIFIC OCEAN, 1916–1917—*Concluded.*

Station	Lat.	Long. East of Gr.	Date	Declination L. M. T.		Declination Value	Wt.	Inclination L. M. T.		Inclination Value	Wt.	Hor. intensity L. M. T.		Hor. intensity Value	Wt.	Instruments Compass	Instruments Dip Circle	Remarks Course	Roll	Sea	Weather
	° ′	° ′	*1917*	h	h	° ′		h	h	° ′		h	h	c. g. s.				°	°		
1269CIV	43 41 S	229 35	Feb 4	17.4	....	18 29 E	2	....	....	....	..	....	....	......	..	C1	....	112	20	R	bo
1270CIV	44 53 S	231 49	Feb 5	8.3	....	19 30 E	1	....	....	....	..	....	....	......	..	C1	....	112	17	M	bo
1271CIV	45 24 S	232 51	Do.	....	....	....	..	14.8	....	59 47 S	2	14.8	....	0.2650	2	D5	EI3,189.1234†	112	14	MR	o
1272CIV	45 42 S	233 29	Do.	18.2	....	20 13 E	2	....	....	....	..	....	....	......	..	C1, D5	....	107	17	R	bo
1273CIV	46 24 S	235 19	Feb 6	5.6	....	20 31 E	2	....	....	....	..	....	....	......	..	C1, D5	....	68	18	MR	bo
1274CIV	46 28 S	237 18	Do.	....	....	....	..	14.6	....	60 06 S	2	14.6	....	.2614	2	D5	EI3,189.1234	73	23	R	bo
1275CIV	46 27 S	237 57	Do.	17.5	....	21 31 E	2	....	....	....	..	....	....	......	..	C1, D5	....	68	13	R	bo
1276CIV	46 46 S	240 58	Feb 7	8.5	....	21 35 E	1	....	....	....	..	....	....	......	..	C1	....	107	20	MR	o
1277CIV	47 08 S	241 44	Do.	....	....	....	..	15.0	....	59 46 S	2	15.0	....	.2617	2	D5	EI3,189.1234†	112	14	R	oq
1278CIV	47 16 S	242 00	Do.	17.0	....	21 40 E	2	....	....	....	..	....	....	......	..	C1, D5	....	112	16	R	o
1280CIV[1]	49 12 S	244 29	Feb 8	....	....	....	..	14.7	....	60 49 S	3	14.6	....	.2580	2	D5	EI3,189.1234	124	23	R	o
1281CIV[2]	49 30 S	244 54	Do.	17.0	....	24 13 E	2	....	....	....	..	....	....	......	..	C1	....	124	23	MR	om
1283CIV	52 14 S	248 13	Feb 9	....	....	....	..	15.0	....	61 57 S	2	15.0	....	.2537	2	D5	EI3,189.1234†	101	20	R	o
1284CIV	54 10 S	252 45	Feb 10	....	....	....	..	14.6	....	62 11 S	2	14.6	....	.2524	2	D5	EI3,189.1234†	73	17	MR	o
1285CIV	54 33 S	257 14	Feb 11	9.5	....	27 37 E	2	....	....	....	..	....	....	......	..	C1	....	107	23	MR	o
1286CIV	54 41 S	258 40	Do.	....	....	....	..	15.0	....	60 54 S	2	14.9	....	.2576	2	D5	EI3,189.1234†	73	20	MR	o
1287CIV	54 43 S	259 01	Do.	15.9	....	29 04 E	2	....	....	....	..	....	....	......	..	C1	....	84	24	MR	o
1288CIV	54 46 S	259 31	Do.	17.8	....	28 09 E	2	....	....	....	..	....	....	......	..	C1, D5	....	73	22	MR	bo
1289CIV	55 07 S	263 14	Feb 12	7.3	....	27 58 E	2	....	....	....	..	....	....	......	..	C1, D5	....	84	20	R	bo
1290CIV	55 24 S	265 18	Do.	....	....	....	..	14.7	....	59 08 S	2	14.7	....	.2624	2	D5	EI3,189.1234†	79	15	R	qr
1291CIV	55 28 S	265 47	Do.	16.2	....	27 56 E	2	....	....	....	..	....	....	......	..	C1	....	84	14	MR	o
1292CIV	55 30 S	266 04	Do.	17.0	....	28 14 E	2	....	....	....	..	....	....	......	..	C1, D5	....	79	15	R	bo
1293CIV	56 00 S	269 44	Feb 13	6.2	....	27 26 E	2	....	....	....	..	....	....	......	..	C1, D5	....	45	19	R	bo
1294CIV	56 16 S	272 08	Do.	....	....	....	..	15.2	....	57 37 S	2	15.2	....	.2635	2	D5	EI3,189.1234†	79	17	MR	bqs
1295CIV	56 20 S	272 39	Do.	17.1	....	26 40 E	2	....	....	....	..	....	....	......	..	C1, D5	....	84	17	R	o
1296CIV	56 43 S	275 48	Feb 14	5.6	....	25 35 E	2	....	....	....	..	....	....	......	..	C1	....	68	18	M	o
1297CIV	56 56 S	277 48	Do.	....	....	....	..	14.6	....	56 22 S	3	14.6	....	.2677	2	D5	EI3,189.1234†	79	16	ML	om
1298CIV	57 34 S	282 49	Feb 15	10.3	....	22 49 E	1	....	....	....	..	....	....	......	..	C1	....	79	20	MR	o
1299CIV	57 34 S	284 02	Do.	....	....	....	..	14.8	....	55 11 S	2	14.7	....	.2675	2	D5	EI3,189.1234†	51	25	MR	bo
1300CIV	57 31 S	284 29	Do.	16.4	....	22 22 E	2	....	....	....	..	....	....	......	..	C1	....	51	25	MR	bo
1301CIV	57 28 S	284 52	Do.	17.8	....	21 53 E	1	....	....	....	..	....	....	......	..	D5	....	51	25	MR	o
1302CIV	56 58 S	288 26	Feb 16	6.9	....	20 28 E	2	....	....	....	..	....	....	......	..	C1	....	51	17	MR	o
1303CIV	56 54 S	288 50	Do.	8.3	....	19 13 E	2	....	....	....	..	....	....	......	..	C1	....	90	17	R	o
1304CIV	56 52 S	289 07	Do.	9.3	....	19 55 E	2	....	....	....	..	....	....	......	..	C1	....	68	15	MR	o
1305CIV	56 40 S	290 23	Do.	....	....	....	..	14.1	....	52 44 S	2	14.1	....	.2687	2	D5	189.1234†	56	17	R	od
1306CIV	56 37 S	290 51	Do.	16.1	....	18 29 E	2	....	....	....	..	....	....	......	..	C1	....	56	15	MR	o
1307CIV	56 35 S	291 18	Do.	17.9	....	18 23 E	2	....	....	....	..	....	....	......	..	D5	....	45	18	M	o

CRUISE IV, ATLANTIC OCEAN, 1917.

Station	Lat.	Long. East of Gr.	Date	Declination L. M. T.		Declination Value	Wt.	Inclination L. M. T.		Inclination Value	Wt.	Hor. intensity L. M. T.		Hor. intensity Value	Wt.	Instruments Compass	Instruments Dip Circle	Remarks Course	Roll	Sea	Weather
	° ′	° ′	*1917*	h	h	° ′		h	h	° ′		h	h	c. g. s.				°	°		
1308CIV	56 05 S	293 34	Feb 17	10.7	....	17 38 E	1	....	....	....	..	....	....	......	..	C1	....	68	15	M	o
1309CIV	55 53 S	294 07	Do.	....	....	....	..	14.7	....	51 18 S	3	14.7	....	0.2676	3	D5	EI3,189.1234†	37	14	M	o
1310CIV	55 50 S	294 18	Do.	16.1	....	16 32 E	2	....	....	....	..	....	....	......	..	C1, D5	....	37	15	M	bo
1311CIV	55 37 S	294 53	Do.	19.2	....	15 59 E	3	....	....	....	..	....	....	......	..	C1, D5	....	37	9	MSL	bo
1312CIV	55 18 S	295 47	Feb 18	5.2	....	15 10 E	2	....	....	....	..	....	....	......	..	C1	....	124	14	M	o
1313CIV	55 03 S	295 51	Do.	....	....	....	..	14.4	....	50 05 S	3	14.4	....	.2674	3	D5	EI3,189.1234†	118	10	M	or
1314CIV	53 34 S	296 54	Feb 19	10.7	....	14 08 E	1	....	....	....	..	....	....	......	..	C1	....	315	10	MS	o
1315CIV	53 28 S	296 54	Do.	....	....	....	..	14.1	....	48 34 S	3	14.1	....	.2651	3	D5	189.1234†	326	12	MS	o
1316CIV	52 26 S	295 42	Feb 20	5.8	....	14 24 E	3	....	....	....	..	....	....	......	..	C1, D5	....	0	8	MSL	b
1317CIV	52 12 S	296 17	Do.	....	....	....	..	14.7	....	47 18 S	3	14.7	....	.2651	2	D5	EI3,189.1234†	48	11	MS	bo
1318CIV	52 03 S	296 45	Do.	17.5	....	13 29 E	3	....	....	....	..	....	....	......	..	C1, D5	....	39	8	M	bo

[1] Station 1279CIV was rejected.

[2] Stations 1281CIV and 1282CIV were combined.

CRUISE IV, ATLANTIC OCEAN, 1917—*Concluded.*

	° ′	° ′	1917	h	h	° ′		h	h	° ′		h	h	c.g.s.				°	°		
1319CIV	50 48 S	298 00	Feb 21	5.8	....	12 26 E	3	....	....	....	..	....	....	......	..	C1, D5	....	11	12	M	b
1320CIV	49 50 S	298 51	Do.	....	....	....	..	15.0	....	44 26 S	2	15.0	....	0.2622	2	D5	EI3,189.1234†	11	15	M	b
1321CIV	49 41 S	298 59	Do.	16.4	....	11 32 E	2	....	....	....	..	....	....	......	..	C1	....	11	12	M	o
1322CIV	48 02 S	299 57	Feb 22	7.0	....	10 24 E	3	....	....	....	..	....	....	......	..	C1, D5	....	11	18	MSL	bo
1323CIV	47 49 S	300 04	Do.	....	....	....	..	15.0	....	42 10 S	2	15.0	....	.2601	3	D5	189.1234†	11	10	SL	bo
1324CIV	47 32 S	300 12	Do.	17.7	....	10 00 E	3	....	....	....	..	....	....	......	..	C1, D5	....	11	5	S	b
1325CIV	46 38 S	300 27	Feb 23	6.1	....	9 38 E	3	....	....	....	..	....	....	......	..	C1, D5	....	45	16	S	bo
1326CIV	46 10 S	300 29	Do.	....	....	....	..	14.1	....	40 20 S	3	14.1	....	.2585	3	D5	189.1234†	315	12	S	b
1327CIV	45 59 S	300 30	Do.	17.5	....	9 19 E	3	....	....	....	..	....	....	......	..	C1, D5	....	11	5	S	b
1328CIV	45 48 S	300 56	Feb 24	8.2	....	8 52 E	2	....	....	....	..	....	....	......	..	C1	....	315	5	S	m
1329CIV	45 26 S	301 02	Do.	....	....	....	..	14.1	....	39 29 S	3	14.1	....	.2568	3	D5	189.1234†	11	8	S	os
1330CIV	43 08 S	301 51	Feb 25	....	....	....	..	15.0	....	37 16 S	2	15.0	....	.2527	2	D5	EI3,189.1234†	11	22	R	or
1331CIV	40 30 S	302 46	Feb 26	8.4	....	5 49 E	2	....	....	....	..	....	....	......	..	C1	....	0	16	M	o
1332CIV	39 41 S	303 09	Do.	....	....	....	..	14.7	....	33 28 S	3	14.7	....	.2478	2	D5	EI3,189.1234†	22	26	MR	bo
1333CIV	39 26 S	303 19	Do.	17.2	....	5 13 E	3	....	....	....	..	....	....	......	..	C1, D5	....	22	21	M	bo
1334CIV	38 29 S	303 55	Feb 27	6.5	....	4 17 E	3	....	....	....	..	....	....	......	..	C1, D5	....	22	18	M	bo
1335CIV	38 09 S	304 06	Do.	....	....	....	..	14.8	....	31 37 S	3	14.8	....	.2464	3	D5	EI3,189.1234†	22	18	LS	o
1336CIV	38 06 S	304 08	Do.	17.8	....	4 03 E	3	....	....	....	..	....	....	......	..	C1, D5	....	338	7	S	o
1337CIV	37 37 S	304 25	Feb 28	6.6	....	3 34 E	3	....	....	....	..	....	....	......	..	C1, D5	....	0	8	S	bo
1338CIV	36 58 S	304 33	Do.	....	....	....	..	14.7	....	30 16 S	3	14.7	....	.2450	3	D5	189.1234†	0	9	S	o
1339CIV	36 43 S	304 32	Do.	17.0	....	3 19 E	3	....	....	....	..	....	....	......	..	C1, D5	....	338	4	S	bo
1340CIV	35 28 S	303 49	Mar 1	6.5	....	3 20 E	3	....	....	....	..	....	....	......	..	C1, D5	....	326	9	S	bc
1341CIV	35 09 S	303 13	Do.	....	....	....	..	14.1	....	28 09 S	3	14.1	....	.2460	3	D5	189.1234†	270	1	S	b
1342CIV	35 08 S	302 58	Do.	18.1	....	4 01 E	3	....	....	....	..	....	....	......	..	C1, D5	....	270	2	S	b
1343CIV[1]	34 41 S	302 02	Mar 2	6.3	....	4 34 E	3	....	....	....	..	....	....	......	..	C1	....	292	0	S	b

CRUISE V, ATLANTIC OCEAN, 1917.

	° ′	° ′	1917	h	h	° ′		h	h	° ′		h	h	c.g.s.				°	°		
1CV	35 17 S	303 19	Dec 6	8.8	....	3 43 E	1	....	....	....	..	....	....	......	..	C1	....	124	5	M	bo
2CV	35 17 S	303 34	Do.	17.5	....	3 31 E	2	....	....	....	..	....	....	......	..	C1	....	34	7	M	bo
3CV	35 43 S	304 05	Dec 7	7.9	....	3 12 E	1	....	....	....	..	....	....	......	..	C1	....	135	4	S	bo
4CV	35 53 S	304 10	Do.	....	....	....	..	14.1	....	29 31 S	3	14.0	....	0.2439	3	D5	189.1234†	158	5	S	bo
5CV	36 15 S	304 21	Do.	17.6	....	2 59 E	3	....	....	....	..	....	....	......	..	C1, D5	....	141	3	MS	bo
6CV	37 31 S	304 59	Dec 8	6.8	....	2 52 E	2	....	....	....	..	....	....	......	..	C1	....	180	8	SL	o
7CV	38 02 S	305 03	Do.	....	....	....	..	14.2	....	31 26 S	3	14.2	....	.2443	3	D5	189.1234†	180	10	S	o
8CV	38 20 S	305 04	Do.	17.2	....	3 04 E	2	....	....	....	..	....	....	......	..	C1, D5	....	180	8	S	oo
9CV	39 07 S	304 45	Dec 9	6.7	....	3 40 E	3	....	....	....	..	....	....	......	..	C1, D5	....	146	6	MS	bo
10CV	39 15 S	304 53	Do.	....	....	....	..	14.1	....	32 50 S	3	14.2	....	.2456	3	D5	189.1234†	292	10	M	bo
11CV	39 04 S	304 38	Do.	17.6	....	3 41 E	3	....	....	....	..	....	....	......	..	C1, D5	....	292	15	MR	bo
12CV	38 53 S	303 33	Dec 10	5.4	....	4 32 E	3	....	....	....	..	....	....	......	..	C1, D5	....	248	15	M	bo
13CV	39 00 S	302 57	Do.	....	....	....	..	14.5	....	32 41 S	3	14.5	....	.2476	3	D5	189.1234†	228	10	SL	bo
14CV	39 01 S	302 55	Do.	17.5	....	5 11 E	3	....	....	....	..	....	....	......	..	C1, D5	....	Var.225	10	SL	bc
15CV	39 48 S	302 32	Dec 11	6.6	....	5 36 E	3	....	....	....	..	....	....	......	..	C1, D5	....	202	15	MS	od
16CV	40 06 S	302 22	Do.	....	....	....	..	15.2	....	34 01 S	3	15.2	....	.2483	3	D5	189.1234†	214	9	SL	o
17CV	40 18 S	302 10	Do.	18.6	....	6 12 E	3	....	....	....	..	....	....	......	..	C1, D5	....	214	12	SL	bo
18CV	41 18 S	301 13	Dec 12	5.0	....	7 18 E	3	....	....	....	..	....	....	......	..	C1, D5	....	214	10	S	bo
19CV	42 15 S	300 17	Do.	....	....	....	..	13.8	....	36 47 S	3	13.8	....	.2528	3	D5	189.1234†	214	3	M	bo
20CV	42 42 S	299 35	Do.	18.6	....	8 55 E	3	....	....	....	..	....	....	......	..	C1, D5	....	225	6	MS	bo
21CV	43 27 S	298 54	Dec 13	5.0	....	9 38 E	2	....	....	....	..	....	....	......	..	C1, D5	....	112	17	M	o
22CV	43 22 S	299 05	Do.	....	....	....	..	15.4	....	37 38 S	1	15.4	....	.2566	1	D5	189.1234†	267	22	R	or
23CV	43 16 S	298 58	Do.	18.7	....	9 38 E	2	....	....	....	..	....	....	......	..	C1, D5	....	270	18	R	bo
24CV	43 04 S	298 44	Dec 14	5.4	....	9 35 E	3	....	....	....	..	....	....	......	..	C1, D5	....	338	16	MS	b
25CV	43 04 S	298 54	Do.	....	....	....	..	14.5	....	37 36 S	3	14.4	....	.2563	3	D5	EI3,189.1234†	112–135	7	SL	bo
26CV	43 00 S	298 54	Do.	19.1	....	9 34 E	3	....	....	....	..	....	....	......	..	C1, D5	....	Var.225	10	SL	bo
27CV	42 42 S	298 12	Dec 15	5.3	....	10 13 E	3	....	....	....	..	....	....	......	..	C1, D5	....	208	13	MS	bo
28CV	44 54 S	297 15	Do.	....	....	....	..	14.2	....	39 56 S	3	14.2	....	.2596	3	D5	EI3,189.1234†	197	12	MS	b

[1] From March 2 to December 6, 1917, the *Carnegie* was at Buenos Aires.

FINAL RESULTS OF OCEAN MAGNETIC OBSERVATIONS ON THE CARNEGIE, 1915–1921—*Continued.*

CRUISE V, ATLANTIC OCEAN, 1917—*Concluded.*

Station	Lat.	Long. East of Gr.	Date	Declination L. M. T.		Declination Value	Wt.	Inclination L. M. T.		Inclination Value	Wt.	Hor. intensity L. M. T.		Hor. intensity Value	Wt.	Instruments Compass	Instruments Dip Circle	Remarks Course	Roll	Sea	Weather
	° ′	° ′	*1917*	h	h	° ′		h	h	° ′		h	h	c. g. s.				°	°		
29CV	45 31 S	296 48	Dec 15	19.2	....	11 46 E	3	....	....	....	..	....	....	......	..	C1, D5	....	197	13	M	bc
30CV	48 50 S	296 49	Dec 16	5.5	....	12 01 E	3	....	....	....	..	....	....	......	..	C1, D5	....	163	12	MS	c
31CV	47 42 S	296 56	Do.	....	....	....	..	14.2	....	42 46 S	3	14.2	....	0.2607	3	D5	EI3,189.1234†	186	7	M	bc
32CV	47 55 S	296 51	Do.	17.9	....	12 43 E	3	....	....	....	..	....	....	......	..	C1, D5	....	186	6	MS	bc
33CV	49 00 S	296 53	Dec 17	4.7	....	12 34 E	3	....	....	....	..	....	....	......	..	C1, D5	....	135	7	MS	bc
34CV	50 06 S	297 33	Do.	....	....	....	..	14.1	....	44 53 S	1	14.1	....	.2655	1	D5	189.1234†	158	26	R	bc
35CV	50 30 S	297 46	Do.	18.8	....	12 32 E	2	....	....	....	..	....	....	......	..	C1, D5	....	158	15	R	bc
36CV	51 04 S	297 52	Dec 18	5.0	....	12 27 E	3	....	....	....	..	....	....	......	..	C1, D5	....	180	11	MS	bcq
37CV	51 38 S	297 56	Do.	....	....	....	..	14.0	....	46 39 S	2	14.0	....	.2659	2	D5	189.1234†	166	10	R	bcqrh
38CV	51 56 S	298 14	Do.	18.7	....	12 23 E	2	....	....	....	..	....	....	......	..	C1, D5	....	141	16	R	bc
39CV	52 45 S	299 19	Dec 19	6.1	....	11 53 E	2	....	....	....	..	....	....	......	..	C1, D5	....	141	16	MR	cqh
40CV	53 15 S	300 18	Do.	....	....	....	..	14.5	....	47 41 S	1	14.5	....	.2641	1	D5	EI3,189.1234†	121	20	R	cqr
41CV	53 25 S	300 53	Do.	19.5	....	11 11 E	2	....	....	....	..	....	....	......	..	C1, D5	....	253	12	R	bcq
42CV	53 14 S	300 33	Dec 20	5.9	....	11 03 E	3	....	....	....	..	....	....	......	..	C1, D5	....	309	14	MS	qbc
43CV	53 08 S	300 13	Do.	....	....	....	..	14.3	....	47 17 S	3	14.3	....	.2639	3	D5	EI3,189.1234†	248	8	M	c
44CV	53 09 S	299 39	Do.	18.7	....	11 58 E	2	....	....	....	..	....	....	......	..	C1, D5	....	253	11	M	bc
45CV	53 30 S	299 38	Dec 21	6.3	....	11 53 E	2	....	....	....	..	....	....	......	..	C1	....	152	11	M	oq
46CV	53 34 S	299 30	Do.	....	....	....	..	13.8	....	48 14 S	3	13.8	....	.2636	3	D5	189.1234†	236	20	MS	o
47CV	53 45 S	299 05	Do.	17.2	....	12 33 E	2	....	....	....	..	....	....	......	..	C1, D5	....	214	15	MS	c
48CV	55 11 S	296 45	Dec 22	....	....	....	..	14.6	....	50 02 S	3	14.5	....	.2663	3	D5	EI3,189.1234†	214	7	MS	od
49CV	55 56 S	295 22	Dec 23	6.3	....	15 20 E	2	....	....	....	..	....	....	......	..	C1	....	141	6	M	or
50CV	56 13 S	295 46	Do.	....	....	....	..	14.7	....	51 14 S	3	14.7	....	.2667	3	D5	EI3,189.1234†	174	21	SL	bc
51CV	56 18 S	295 50	Do.	16.5	....	15 19 E	2	....	....	....	..	....	....	......	..	C1	....	180	15	SL	bc
52CV	56 54 S	294 50	Dec 24	3.6	....	16 16 E	3	....	....	....	..	....	....	......	..	C1, D5	....	219	13	M	c

CRUISE V, PACIFIC OCEAN, 1917–1918.

Station	Lat.	Long. East of Gr.	Date	Declination L. M. T.		Declination Value	Wt.	Inclination L. M. T.		Inclination Value	Wt.	Hor. intensity L. M. T.		Hor. intensity Value	Wt.	Instruments Compass	Instruments Dip Circle	Remarks Course	Roll	Sea	Weather
	° ′	° ′	*1917*	h	h	° ′		h	h	° ′		h	h	c. g. s.				°	°		
53CV	57 41 S	291 47	Dec 24	....	....	....	..	14.8	....	53 38 S	2	14.8	....	0.2660	2	D5	189.1234†	236	12	R	md
54CV	58 00 S	291 00	Do.	19.4	....	18 29 E	3	....	....	....	..	....	....	......	..	C1, D5	....	208	10	R	bc
55CV	58 29 S	289 17	Dec 25	5.1	....	20 26 E	2	....	....	....	..	....	....	......	..	C1, D5	....	231	30	R	bcq
56CV	58 56 S	288 07	Do.	....	....	....	..	15.2	....	55 13 S	2	15.1	....	.2648	2	D5	EI3,189.1234†	233	19	R	bc
57CV	58 57 S	287 46	Do.	18.7	....	20 50 E	2	....	....	....	..	....	....	......	..	C1, D5	....	259	13	R	od
58CV	58 33 S	286 14	Dec 26	6.1	....	22 09 E	2	....	....	....	..	....	....	......	..	C1	....	292	8	R	or
59CV[1]	58 11 S	285 44	Do.	....	....	....	..	14.7	....	55 19 S	1	14.7	....	.2642	1	D5	189.1234†	340	18	R	d
60CV	57 32 S	286 28	Dec 27	5.5	....	21 37 E	2	....	....	....	..	....	....	......	..	C1, D5	....	349	25	R	cq
61CV	57 44 S	286 17	Do.	....	....	....	..	14.4	....	54 40 S	2	14.3	....	.2672	2	D5	EI3,189.1234†	225	21	R	bc
62CV	57 52 S	285 55	Do.	19.6	....	21 38 E	2	....	....	....	..	....	....	......	..	C1, D5	....	231	16	MR	bcq
63CV	58 14 S	285 23	Dec 28	4.5	....	22 08 E	2	....	....	....	..	....	....	......	..	C1, D5	....	219	12	MR	bcqr
64CV	58 38 S	284 40	Do.	....	....	....	..	14.3	....	55 55 S	3	14.3	....	.2666	3	D5	EI3,189.1234†	211	13	M	bc
65CV	59 08 S	284 22	Dec 29	9.3	....	22 36 E	1	....	....	....	..	....	....	......	..	C1	....	Var.292	12	S	bc
66CV	59 08 S	284 14	Do.	....	....	....	..	13.9	....	56 18 S	3	14.0	....	.2650	3	D5	189.1234†	250	12	SL	o
67CV	59 06 S	283 41	Do.	16.7	....	23 05 E	2	....	....	....	..	....	....	......	..	C1	....	287	11	SL	o
68CV	58 45 S	282 05	Dec 30	5.4	....	23 38 E	3	....	....	....	..	....	....	......	..	C1, D5	....	248	10	MS	bcq
69CV	58 25 S	280 42	Do.	....	....	....	..	14.8	....	56 47 S	2	14.8	....	.2647	2	D5	189.1234†	281	12	M	od
70CV	58 17 S	280 30	Do.	17.0	....	24 15 E	2	....	....	....	..	....	....	......	..	C1	....	304	14	MS	c
71CV	55 30 S	279 38	Dec 31	....	....	....	..	15.0	....	54 35 S	3	15.0	....	.2712	2	D5	EI3,189.1234†	323	15	MR	o

[1] Hove to in a gale.

CRUISE V, PACIFIC OCEAN, 1917–1918—*Continued.*

	° ′	° ′	1918	h	h	° ′		h	h	° ′		h	h	c. g. s.				°	°		
72CV	53 06 S	279 44	Jan 1	8.6	....	23 28 E	1	....	....	....	..	....	....	......	..	C1	....	82	13	M	om
73CV	52 12 S	280 10	Do.	....	....	....	..	14.6	....	51 46 S	2	14.6	....	0.2722	2	D5	EI3,189.1234†	349	9	MR	oqr
74CV	51 44 S	280 25	Do.	17.9	....	22 11 E	1	....	....	....	..	....	....	......	..	C1	....	349	10	R	o
75CV	52 15 S	278 55	Jan 2	....	....	....	..	14.4	....	52 10 S	1	14.4	....	.2714	1	D5	EI3,189.1234†	217	23	R	om
76CV	52 23 S	278 50	Do.	15.9	....	23 12 E	2	....	....	....	..	....	....	......	..	C1	....	214	21	R	o
77CV	52 27 S	278 57	Jan 3	4.9	....	23 07 E	2	....	....	....	..	....	....	......	..	C1, D5	....	326	20	R	bc
78CV	51 50 S	279 15	Do.	....	....	....	..	14.6	....	51 35 S	2	14.6	....	.2715	2	D5	EI3,189.1234†	245	14	R	bcq
79CV	51 35 S	279 25	Do.	17.7	....	22 23 E	2	....	....	....	..	....	....	......	..	C1, D5	....	349	25	R	bcq
80CV	50 45 S	279 53	Jan 4	5.7	....	22 35 E	2	....	....	....	..	....	....	......	..	C1, D5	....	326	10	MR	o
81CV	50 17 S	279 54	Do.	....	....	....	..	15.0	....	49 56 S	3	14.9	....	.2737	3	D5	EI3,189.1234†	152	14	ML	cq
82CV	49 55 S	279 50	Do.	17.7	....	21 37 E	3	....	....	....	..	....	....	......	..	C1, D5	....	326	9	ML	bc
83CV	48 29 S	279 36	Jan 5	5.9	....	22 01 E	3	....	....	....	..	....	....	......	..	C1, D5	....	326	15	ML	cq
84CV	47 15 S	279 24	Do.	....	....	....	..	14.8	....	47 41 S	3	14.8	....	.2733	3	D5	EI3,189.1234†	298	16	ML	bc
85CV	46 48 S	279 27	Do.	18.0	....	21 31 E	3	....	....	....	..	....	....	......	..	C1, D5	....	298	16	ML	bc
86CV	45 18 S	280 05	Jan 6	7.0	....	20 20 E	2	....	....	....	..	....	....	......	..	C1	....	338	9	M	o
87CV[1]	44 26 S	280 29	Do.	....	....	....	..	14.8	....	44 51 S	2	14.7	....	.2742	3	D5	EI3,189.1234†	0	13	MS	c
89CV	43 00 S	281 17	Jan 7	9.2	....	19 26 E	1	....	....	....	..	....	....	......	..	C1	....	0	10	MS	c
90CV	42 43 S	281 28	Do.	....	....	....	..	15.3	....	42 43 S	3	15.3	....	.2721	3	D5	EI3,189.1234†	8	9	MS	bc
91CV	42 37 S	281 32	Do.	17.1	....	19 43 E	2	....	....	....	..	....	....	......	..	C1	....	6	9	S	bc
92CV	41 57 S	282 00	Jan 8	7.0	....	18 36 E	3	....	....	....	..	....	....	......	..	C1	....	349	7	S	o
93CV	41 22 S	282 25	Do.	....	....	....	..	14.6	....	41 27 S	3	14.6	....	.2708	3	D5	EI3,189.1234†	6	7	S	o
94CV[2]	41 05 S	282 37	Do.	18.0	....	18 30 E	2	....	....	....	..	....	....	......	..	C1	....	6	7	S	o
96CV	39 09 S	283 36	Jan 9	....	....	....	..	14.6	....	38 44 S	3	14.6	....	.2683	3	D5	EI3,189.1234†	22	18	M	o
97CV	38 57 S	283 46	Do.	16.2	....	17 32 E	2	....	....	....	..	....	....	......	..	C1	....	22	12	M	o
98CV	37 21 S	285 29	Jan 10	5.6	....	15 53 E	3	....	....	....	..	....	....	......	..	C1, D5	....	0	10	M	b
99CV	36 45 S	286 28	Do.	....	....	....	..	14.4	....	35 05 S	3	14.4	....	.2650	3	D5	EI3,189.1234†	28	7	SL	b
100CV[3]	36 34 S	286 44	Do.	17.8	....	15 20 E	3	....	....	....	..	....	....	......	..	C1, D5	....	73	6	S	b
101CV	36 23 S	286 49	Jan 23	....	....	....	..	14.0	....	34 26 S	3	14.0	....	.2650	3	D5	189.1234†	323	9	SL	bc
102CV	36 09 S	286 41	Do.	17.5	....	15 05 E	2	....	....	....	..	....	....	......	..	C1	....	321	6	S	c
103CV	35 33 S	286 13	Jan 24	6.4	....	14 53 E	2	....	....	....	..	....	....	......	..	C1	....	321	26	SL	o
104CV	35 30 S	286 11	Do.	7.5	....	15 01 E	2	....	....	....	..	....	....	......	..	C1	....	321	26	SL	o
105CV	35 11 S	285 57	Do.	....	....	....	..	15.0	....	33 31 S	2	15.0	....	.2684	2	D5	EI3,189.1234†	321	23	SL	b
106CV	34 56 S	285 47	Do.	18.0	....	15 04 E	3	....	....	....	..	....	....	......	..	C1, D5	....	321	14	SL	b
107CV	33 45 S	285 10	Jan 25	5.6	....	14 39 E	3	....	....	....	..	....	....	......	..	C1, D5	....	321	18	ML	b
108CV	32 49 S	284 46	Do.	....	....	....	..	14.8	....	31 31 S	2	14.8	....	.2668	2	D5	EI3,189.1234†	323	18	SL	bc
109CV	32 34 S	284 38	Do.	17.4	....	14 52 E	3	....	....	....	..	....	....	......	..	C1, D5	....	321	17	SL	bc
110CV	31 30 S	284 08	Jan 26	5.9	....	14 35 E	3	....	....	....	..	....	....	......	..	C1, D5	....	321	12	SL	bc
111CV	31 15 S	284 05	Do.	....	....	....	..	14.8	....	29 59 S	3	14.8	....	.2682	3	D5	EI3,189.1234†	309	12	SL	bc
112CV	31 04 S	283 56	Do.	17.5	....	14 43 E	3	....	....	....	..	....	....	......	..	C1, D5	....	309	6	SL	bc
113CV	30 48 S	283 40	Jan 27	5.8	....	14 37 E	3	....	....	....	..	....	....	......	..	C1, D5	....	Var. 0	12	SL	bc
114CV	30 47 S	283 31	Do.	....	....	....	..	14.8	....	29 31 S	3	14.8	....	.2702	3	D5	EI3,189.1234†	340	7	M	bc
115CV	30 30 S	283 15	Do.	17.4	....	14 52 E	3	....	....	....	..	....	....	......	..	C1, D5	....	298	7	MS	bc
116CV	29 28 S	282 09	Jan 28	5.6	....	14 40 E	3	....	....	....	..	....	....	......	..	C1, D5	....	292	18	MS	bc
117CV	28 54 S	281 21	Do.	....	....	....	..	14.6	....	28 20 S	3	14.6	....	.2753	3	D5	EI3,189.1234†	292	14	MS	bc
118CV	28 40 S	280 59	Do.	17.3	....	14 36 E	2	....	....	....	..	....	....	......	..	C1	....	292	14	M	c
119CV	28 34 S	280 50	Do.	18.5	....	14 49 E	2	....	....	....	..	....	....	......	..	C1, D5	....	292	12	MS	c
120CV	27 36 S	279 14	Jan 29	8.7	....	14 23 E	2	....	....	....	..	....	....	......	..	C1	....	248	30	ML	c
121CV	27 24 S	278 33	Do.	....	....	....	..	15.4	....	28 21 S	3	14.8	....	.2765	3	D5	EI3,189.1234†	276	15	ML	bc
122CV	27 17 S	278 08	Do.	17.8	....	15 03 E	2	....	....	....	..	....	....	......	..	C1, D5	....	304	18	ML	bc
123CV	27 16 S	278 04	Do.	18.2	....	14 56 E	2	....	....	....	..	....	....	......	..	C1, D5	....	304	9	ML	bc
124CV	27 52 S	276 08	Jan 30	5.9	....	15 17 E	2	....	....	....	..	....	....	......	..	C1, D5	....	219	10	M	c
125CV	28 18 S	275 21	Do.	....	....	....	..	14.6	....	30 43 S	2	14.6	....	.2802	2	D5	189.1234†	208	15	MR	bc
126CV	28 34 S	274 59	Do.	18.2	....	15 23 E	2	....	....	....	..	....	....	......	..	C1, D5	....	219	8	MR	bc
127CV	29 24 S	273 31	Jan 31	7.9	....	16 25 E	2	....	....	....	..	....	....	......	..	C1, D5	....	214	14	MR	bc
128CV	29 47 S	272 51	Do.	....	....	....	..	14.9	....	33 44 S	2	14.8	....	.2789	2	D5	EI3,189.1234†	200	14	R	bc
129CV	30 06 S	272 32	Do.	18.4	....	16 31 E	2	....	....	....	..	....	....	......	..	C1	....	202	15	R	c
130CV	31 05 S	271 44	Feb 1	6.8	....	16 55 E	2	....	....	....	..	....	....	......	..	C1	....	191	14	R	o

[1] 88CV rejected. [2] 95CV rejected. [3] From January 11 to January 22 the *Carnegie* was at Talcahuano, Chile.

FINAL RESULTS OF OCEAN MAGNETIC OBSERVATIONS ON THE CARNEGIE, 1915–1921—*Continued.*

CRUISE V, PACIFIC OCEAN, 1917–1918 *Continued.*

Station	Lat.	Long. East of Gr.	Date	Declination L. M. T.		Declination Value	Declination Wt.	Inclination L. M. T.		Inclination Value	Inclination Wt.	Hor. intensity L. M. T.		Hor. intensity Value	Hor. intensity Wt.	Instruments Compass	Instruments Dip Circle	Remarks Course	Remarks Roll	Remarks Sea	Weather
	° ′	° ′	*1918*	h	h	° ′		h	h	° ′		h	h	c. g. s.				°	°		
131CV	31 41 S	271 06	Feb 1	....	....	....	..	14.8	....	36 42 S	3	14.8	....	0.2802	3	D5	EI3,189.1234†	194	15	M	o
132CV	31 59 S	270 45	Do.	18.7	....	17 12 E	2	....	....	....	..	....	....	......	..	C1	....	202	9	M	o
133CV	32 44 S	269 30	Feb 2	8.7	....	17 46 E	2	....	....	....	..	....	....	......	..	C1	....	174	9	S	o
134CV	33 23 S	269 06	Do.	....	....	....	..	14.6	....	39 26 S	3	14.6	....	.2809	3	D5	EI3,189.1234†	183	12	MS	bc
135CV	33 55 S	268 49	Do.	18.8	....	18 29 E	2	....	....	....	..	....	....	......	..	C1, D5	....	186	8	M	c
136CV	35 07 S	268 10	Feb 3	8.0	....	18 47 E	2	....	....	....	..	....	....	......	..	C1	....	174	5	S	o
137CV	35 42 S	268 12	Do.	....	....	....	..	14.6	....	42 11 S	3	14.6	....	.2780	3	D5	EI3,189.1234†	152	9	S	o
138CV	36 52 S	268 25	Feb 4	6.6	....	19 26 E	3	....	....	....	..	....	....	......	..	C1, D5	....	112	7	S.	c
139CV	36 56 S	268 51	Do.	....	....	....	..	14.6	....	43 18 S	3	14.6	....	.2766	3	D5	EI3,189.1234†	73	5	S	bc
140CV	36 58 S	268 58	Do.	18.0	....	19 50 E	3	....	....	....	..	....	....	......	..	C1, D5	....	73	4	S	bc
141CV	36 57 S	269 54	Feb 5	9.1	....	19 58 E	2	....	....	....	..	....	....	......	..	C1	....	124	3	S	c
142CV	36 55 S	270 20	Do.	....	....	....	..	14.8	....	42 28 S	3	14.7	....	.2781	3	D5	EI3,189.1234†	68	6	S	c
143CV	36 54 S	270 30	Do.	17.4	....	19 43 E	3	....	....	....	..	....	....	......	..	C1, D5	....	51	4	S	bc
144CV	36 57 S	271 31	Feb 6	6.4	....	19 59 E	3	....	....	....	..	....	....	......	..	C1, D5	....	51	5	S	bc
145CV	36 58 S	272 25	Do.	....	....	....	..	14.8	....	41 28 S	3	14.7	....	.2770	3	D5	EI3,189.1234†	68	6	S	bc
146CV	36 58 S	272 47	Do.	17.5	....	19 16 E	3	....	....	....	..	....	....	......	..	C1, D5	....	51	8	S	bc
147CV	36 58 S	274 11	Feb 7	5.7	....	19 13 E	3	....	....	....	..	....	....	......	..	C1, D5	....	68	7	S	bc
148CV	36 57 S	275 28	Do.	....	....	....	..	14.6	....	40 12 S	3	14.6	....	.2751	3	D5	EI3,189.1234†	70	10	S	bc
149CV	36 56 S	275 55	Do.	17.3	....	18 54 E	2	....	....	....	..	....	....	......	..	C1	....	56	5	S	c
150CV	36 56 S	276 02	Do.	18.1	....	18 58 E	3	....	....	....	..	....	....	......	..	C1, D5	....	45	3	S	bc
151CV	36 29 S	277 42	Feb 8	5.8	....	18 17 E	3	....	....	....	..	....	....	......	..	C1, D5	....	45	6	S	c
152CV	35 54 S	278 43	Do.	....	....	....	..	14.4	....	37 35 S	3	14.8	....	.2726	3	D5	EI3,189.1234†	20	7	S	bc
153CV	35 38 S	279 02	Do.	17.5	...	17 29 E	2	....	....	....	..	....	....	......	..	C1	....	22	5	MS	c
154CV	34 41 S	278 56	Feb 9	6.2	....	17 28 E	3	....	....	....	..	....	....	......	..	C1, D5	....	326	16	MS	c
155CV	33 59 S	278 42	Do.	....	....	....	..	14.6	....	35 31 S	3	14.6	....	.2722	3	D5	EI3,189.1234†	343	11	MS	bc
156CV	32 27 S	278 34	Feb 10	5.7	....	16 22 E	3	....	....	....	..	....	....	......	..	C1, D5	....	343	11	MSL	bc
157CV	31 49 S	278 36	Do.	....	....	....	..	14.6	....	33 01 S	3	14.5	....	.2748	3	D5	EI3,189.1234†	343	12	ML	bc
158CV	31 36 S	278 36	Do.	17.5	....	16 25 E	3	....	....	....	..	....	....	......	..	C1, D5	....	343	14	MSL	bc
159CV	30 41 S	278 27	Feb 11	7.2	....	16 07 E	2	....	....	....	..	....	....	......	..	C1, D5	....	343	8	MS	c
160CV	30 06 S	278 21	Do.	....	....	....	..	14.6	....	31 17 S	3	14.6	....	.2752	3	D5	EI3,189.1234†	335	22	ML	bc
161CV	30 00 S	278 18	Do.	15.8	....	15 56 E	2	....	....	....	..	....	....	......	..	C1	....	335	17	SL	bc
162CV	29 55 S	278 19	Do.	16.8	....	15 59 E	2	....	....	....	..	....	....	......	..	C1	....	6	17	SL	bc
163CV	29 51 S	278 22	Do.	17.8	....	15 58 E	3	....	....	....	..	....	....	......	..	C1, D5	....	6	16	MSL	bc
164CV	28 18 S	278 11	Feb 12	9.3	....	15 22 E	2	....	....	....	..	....	....	......	..	C1	....	343	16	M	o
165CV	27 51 S	278 09	Do.	....	....	....	..	14.6	....	28 44 S	3	14.6	....	.2762	3	D5	EI3,189.1234†	343	14	SL	bc
166CV	27 32 S	278 08	Do.	17.5	....	14 59 E	3	....	....	....	..	....	....	......	..	C1, D5	....	346	7	MSL	bc
167CV	26 09 S	278 06	Feb 13	6.8	....	14 16 E	3	....	....	....	..	....	....	......	..	C1, D5	....	346	5	ML	c
168CV	25 27 S	278 14	Do.	....	....	....	..	14.7	....	25 42 S	2	14.7	....	.2797	2	D5	EI3,189.1234†	3	16	ML	bc
169CV	25 15 S	278 15	Do.	17.4	....	14 01 E	3	....	....	....	..	....	....	......	..	C1, D5	....	3	15	ML	bc
170CV	24 06 S	278 29	Feb 14	8.9	....	13 49 E	2	....	....	....	..	....	....	......	..	C1	....	3	5	SL	o
171CV	23 53 S	278 32	Do.	....	....	....	..	14.6	....	23 05 S	3	14.6	....	.2816	3	D5	EI3,189.1234†	11	8	SL	bc
172CV	23 46 S	278 35	Do.	16.7	....	13 43 E	3	....	....	....	..	....	....	......	..	C1, D5	....	11	8	SL	bc
173CV	22 41 S	278 57	Feb 15	8.5	....	12 47 E	2	....	....	....	..	....	....	......	..	C1	....	11	5	S	c
174CV	22 20 S	279 01	Do.	....	....	....	..	14.4	....	20 43 S	3	14.4	....	.2840	3	D5	EI3,189.1234†	17	6	S	c
175CV	22 08 S	279 09	Do.	17.8	....	12 59 E	3	....	....	....	..	....	....	......	..	C1	....	17	5	S	o
176CV	21 02 S	279 44	Feb 16	8.1	....	12 02 E	2	....	....	....	..	....	....	......	..	C1	....	22	4	S	o
177CV	20 47 S	279 50	Do.	....	....	....	..	14.7	....	17 41 S	3	14.7	....	.2868	3	D5	EI3,189.1234†	34	7	SL	bc
178CV	19 51 S	280 28	Feb 17	9.8	....	12 00 E	1	....	....	....	..	....	....	......	..	C1	....	34	5	S	o
179CV	19 36 S	280 40	Do.	....	....	....	..	14.6	....	15 12 S	3	14.6	....	.2874	3	D5	EI3,189.1234†	34	6	S	c

CRUISE V, PACIFIC OCEAN, 1917–1918 *Continued.*

	° ′	° ′	*1918*	h	h	° ′		h	h	° ′		h	h	c.g.s.				°	°		
180CV	19 25 S	280 50	Feb 17	16.8	....	11 20 E	2	....	....	....	..	....	....	....	..	C1	....	34	4	S	c
181CV	18 35 S	281 32	Feb 18	6.5	....	11 02 E	3	....	....	....	..	....	....	....	..	C1, D5	....	34	6	S	bc
182CV	18 07 S	281 40	Do.	....	....	....	..	14.6	....	12 08 S	3	14.6	....	0.2909	3	D5	EI3,189.1234†	0	6	S	bc
183CV	17 53 S	281 43	Do.	17.0	....	11 02 E	2	....	....	....	..	....	....	....	..	C1	....	0	6	S	cs
184CV	16 48 S	281 50	Feb 19	7.1	....	10 50 E	3	....	....	....	..	....	....	....	..	C1, D5	....	0	6	SL	c
185CV	16 16 S	281 53	Do.	....	....	....	..	14.4	....	8 43 S	3	14.4	....	.2946	3	D5	EI3,189.1234†	3	6	S	bc
186CV	16 04 S	281 55	Do.	17.1	....	10 11 E	2	....	....	....	..	....	....	....	..	C1	....	3	5	MS	c
187CV	14 48 S	282 07	Feb 20	6.2	....	9 52 E	3	....	....	....	..	....	....	....	..	C1, D5	....	6	6	MS	bc
188CV	14 09 S	282 10	Do.	....	....	....	..	14.5	....	5 13 S	3	14.5	....	.2965	3	D5	EI3,189.1234†	11	7	S	bc
189CV	14 01 S	282 11	Do.	17.5	....	9 33 E	3	....	....	....	..	....	....	....	..	C1, D5	....	22	6	S	b
190CV	13 34 S	282 22	Feb 21	6.3	....	9 35 E	3	....	....	....	..	....	....	....	..	C1, D5	....	22	9	S	bc
191CV	13 05 S	282 38	Do.	....	....	....	..	14.8	....	2 47 S	3	14.8	....	.2984	3	D5	EI3,189.1234†	8,349	8	S	bc
192CV	12 57 S	282 38	Do.	17.5	....	9 11 E	3	....	....	....	..	....	....	....	..	C1, D5	....	349	5	S	c
193CV	12 17 S	282 36	Feb 22	....	....	....	..	14.0	....	1 20 S	3	14.0	....	.2998	3	D5	189.1234†	28	7	S	bc
194CV[1]	11 53 S	282 32	Mar 29	....	....	....	..	14.1	....	0 26 S	3	14.1	....	.2989	3	D5	189.1234†	304	13	SL	bc
195CV	11 42 S	282 19	Do.	17.6	....	8 37 E	3	....	....	....	..	....	....	....	..	C1, D5	....	304	11	SL	c
196CV	11 06 S	281 41	Mar 30	6.3	....	8 48 E	3	....	....	....	..	....	....	....	..	C1, D5	....	304	8	SL	bc
197CV	10 56 S	281 19	Do.	....	....	....	..	14.8	....	0 18 N	3	14.7	....	.3034	3	D5	EI3,189.1234†	287	14	SL	c
198CV	10 49 S	281 06	Do.	17.4	....	8 58 E	3	....	....	....	..	....	....	....	..	C1, D5	....	287	11	SL	c
199CV	10 14 S	280 02	Mar 31	6.6	....	9 02 E	3	....	....	....	..	....	....	....	..	C1, D5	....	287	16	MSL	bc
200CV	9 58 S	279 12	Do.	....	....	....	..	14.7	....	1 19 N	2	14.7	....	.3090	2	D5	EI3,189.1234†	259	17	MSL	c
201CV	9 57 S	278 52	Do.	17.5	....	9 13 E	2	....	....	....	..	....	....	....	..	C1	....	248	11	ML	c
202CV	10 01 S	277 43	Apr 1	6.5	....	9 19 E	3	....	....	....	..	....	....	....	..	C1, D5	....	281	14	MSL	bc
203CV	10 19 S	277 01	Do.	....	....	....	..	14.6	....	0 20 S	3	14.6	....	.3100	3	D5	EI3,189.1234†	233	13	ML	bc
204CV	10 25 S	276 45	Do.	17.3	....	9 52 E	3	....	....	....	..	....	....	....	..	C1, D5	....	228	10	ML	bc
205CV	11 09 S	275 26	Apr 2	6.5	....	10 15 E	3	....	....	....	..	....	....	....	..	C1, D5	....	225	9	MSL	bc
206CV	11 28 S	274 50	Do.	....	....	....	..	14.4	....	3 52 S	3	14.4	....	.3094	3	D5	EI3,189.1234†	225	13	MS	bc
207CV	11 32 S	274 41	Do.	17.2	....	10 17 E	2	....	....	....	..	....	....	....	..	C1, D5	....	225	12	MS	bc
208CV	12 07 S	273 46	Apr 3	6.1	....	10 35 E	2	....	....	....	..	....	....	....	..	C1	....	219	10	ML	oqr
209CV	12 10 S	273 42	Do.	7.0	....	10 37 E	3	....	....	....	..	....	....	....	..	C1, D5	....	214	12	MSL	oqr
210CV	12 33 S	273 11	Do.	....	....	....	..	14.6	....	6 34 S	3	14.6	....	.3097	3	D5	EI3,189.1234†	219	16	MR	oqrbc
211CV	12 43 S	272 59	Do.	16.5	....	10 48 E	3	....	....	....	..	....	....	....	..	C1, D5	....	219	12	MR	bc
212CV	13 47 S	271 38	Apr 4	6.4	....	11 13 E	3	....	....	....	..	....	....	....	..	C1, D5	....	214	12	MR	bc
213CV	14 23 S	270 50	Do.	....	....	....	..	14.7	....	11 06 S	2	14.7	....	.3061	2	D5	EI3,189.1234†	214	14	R	bc
214CV	15 38 S	269 18	Apr 5	7.4	....	11 47 E	2	....	....	....	..	....	....	....	..	C1, D5	....	214	9	MR	c
215CV	16 13 S	268 34	Do.	....	....	....	..	15.0	....	15 45 S	3	15.0	....	.3047	3	D5	EI3,189.1234†	214	16	M	c
216CV	16 16 S	268 30	Do.	15.8	....	12 11 E	2	....	....	....	..	....	....	....	..	C1	....	186	16	M	c
217CV	16 13 S	266 58	Apr 6	6.6	....	11 56 E	3	....	....	....	..	....	....	....	..	C1, D5	....	231	12	ML	bc
218CV	16 05 S	266 05	Do.	....	....	....	..	14.3	....	16 29 S	3	14.3	....	.3056	3	D5	EI3,189.1234†	273	12	M	bc
219CV	15 59 S	265 45	Do.	17.2	....	11 46 E	3	....	....	....	..	....	....	....	..	C1, D5	....	321	12	M	bc
220CV	15 36 S	263 38	Apr 7	10.3	....	11 30 E	1	....	....	....	..	....	....	....	..	C1	....	270	10	M	c
221CV	15 25 S	263 22	Do.	....	....	....	..	14.2	....	16 34 S	3	14.2	....	.3101	3	D5	EI3,189.1234†	349	11	ML	bc
222CV	15 02 S	263 19	Do.	17.4	....	11 46 E	3	....	....	....	..	....	....	....	..	C1, D5	....	349	7	ML	bc
223CV	14 01 S	264 04	Apr 8	7.5	....	11 25 E	3	....	....	....	..	....	....	....	..	C1, D5	....	22	17	MRL	c
224CV	13 32 S	264 20	Do.	....	....	....	..	14.4	....	12 46 S	2	14.4	....	.3122	2	D5	EI3,189.1234†	34	10	MRL	bc
225CV	13 18 S	264 30	Do.	17.3	....	11 36 E	3	....	....	....	..	....	....	....	..	C1, D5	....	34	10	MR	bc
226CV	12 25 S	264 52	Apr 9	6.4	....	11 07 E	3	....	....	....	..	....	....	....	..	C1, D5	....	11,22	9	M	bc
227CV	11 59 S	265 04	Do.	....	....	....	..	14.4	....	9 23 S	3	14.4	....	.3159	3	D5	EI3,189.1234†	22	12	MS	bc
228CV	11 48 S	265 10	Do.	17.4	....	11 19 E	3	....	....	....	..	....	....	....	..	C1, D5	....	22	12	MSL	bc
229CV	10 53 S	265 45	Apr 10	6.6	....	10 43 E	3	....	....	....	..	....	....	....	..	C1, D5	....	28	8	SL	bc
230CV	10 28 S	266 06	Do.	....	....	....	..	14.2	....	6 26 S	3	14.2	....	.3184	3	D5	EI3,189.1234†	39	8	SL	bc
231CV	10 16 S	266 14	Do.	17.5	....	10 53 E	3	....	....	....	..	....	....	....	..	C1, D5	....	37	10	SL	b
232CV	9 14 S	267 00	Apr 11	6.6	....	10 37 E	2	....	....	....	..	....	....	....	..	C1	....	34	10	SL	c
233CV	9 08 S	267 05	Do.	7.9	....	10 46 E	2	....	....	....	..	....	....	....	..	C1	....	24	10	M	c
234CV	8 36 S	267 33	Do.	....	....	....	..	14.4	....	2 02 S	2	14.4	....	.3208	2	D5	EI3,189.1234†	39	10	ML	bc
235CV	8 24 S	267 44	Do.	17.0	....	10 34 E	3	....	....	....	..	....	....	....	..	C1, D5	....	45	8	ML	bc
236CV	7 43 S	268 30	Apr 12	7.2	....	10 04 E	2	....	....	....	..	....	....	....	..	C1	....	42	10	MR	c
237CV	7 21 S	268 53	Do.	....	....	....	..	14.4	....	0 56 N	2	14.3	....	.3220	2	D5	EI3,189.1234†	45	10	ML	bc

[1] From February 23 to March 28 the Carnegie was at Callao.

FINAL RESULTS OF OCEAN MAGNETIC OBSERVATIONS ON THE CARNEGIE, 1915–1921—*Continued.*

CRUISE V, PACIFIC OCEAN, 1917–1918 *Concluded.*

Station	Lat.	Long. East of Gr.	Date	Declination L. M. T.		Declination Value	Declination Wt.	Inclination L. M. T.		Inclination Value	Inclination Wt.	Hor. intensity L. M. T.		Hor. intensity Value	Hor. intensity Wt.	Instruments Compass	Instruments Dip Circle	Remarks Course	Remarks Roll	Remarks Sea	Weather
	° ′	° ′	*1918*	h	h	° ′		h	h	° ′		h	h	c. g. s.				°	°		
238CV	7 13 S	269 00	Apr 12	17.1		10 18 E	3									C1, D5		45	11	ML	bc
239CV	6 31 S	269 47	Apr 13	7.9		9 43 E	2									C1		28	8	ML	c
240CV	6 17 S	270 07	Do.					14.5		3 51 N	3	14.5		0.3237	3	D5	EI3,189.1234†	48	14	ML	c
241CV	6 14 S	270 12	Do.	16.3		9 54 E	2									C1		42	10	ML	c
242CV	5 38 S	271 28	Apr 14	6.6		9 39 E	2									C1, D5		51	10	R	bc
243CV	5 08 S	272 14	Do.					14.4		7 07 N	2	14.4		.3236	2	D5	EI3,189.1234†	34	12	MR	bc
244CV	5 00 S	272 22	Do.	16.2		9 19 E	2									C1		34	9	MR	c
245CV	4 52 S	272 31	Do.	17.8		9 21 E	2									C1		34	8	M	c
246CV	3 54 S	273 33	Apr 15	8.7		8 56 E	2									C1		17	10	ML	oq
247CV	3 25 S	273 42	Do.					14.6		10 59 N	3	14.6		.3242	3	D5	EI3,189.1234†	14	12	MSL	bc
248CV	3 12 S	273 45	Do.	17.1		8 44 E	3									C1, D5		11	9	MSL	bc
249CV	2 22 S	274 14	Apr 16	6.5		8 30 E	3									C1, D5		39	6	MSL	bc
250CV	1 57 S	274 32	Do.					14.2		14 32 N	3	14.2		.3252	3	D5	EI3,189.1234†	34	8	MSL	bc
251CV	1 49 S	274 36	Do.	17.4		8 20 E	3									C1, D5		34	7	SL	bc
252CV	1 27 S	275 04	Apr 17	8.0		8 11 E	2									C1		39	6	SL	c
253CV	1 04 S	275 27	Do.					14.3		16 30 N	3	14.3		.3264	3	D5	EI3,189.1234†	45	6	SL	bc
254CV	0 56 S	275 37	Do.	17.2		7 56 E	3									C1, D5		51	5	SL	bc
255CV	0 04 S	276 27	Apr 18	6.4		7 44 E	3									C1, D5		68	7	SL	bc
256CV	0 17 N	277 06	Do.					14.4		19 44 N	3	14.4		.3260	3	D5	EI3,189.1234†	73	8	S	bc
257CV	0 23 N	277 20	Do.	17.4		7 13 E	3									C1, D5		39	5	S	bc
258CV	1 22 N	278 08	Apr 19	7.1		6 52 E	3									C1, D5		11	4	S	bc
259CV	1 48 N	278 35	Do.					14.3		22 58 N	3	14.3		.3237	3	D5	EI3,189.1234†	51	5	S	c
260CV	1 55 N	278 44	Do.	17.0		6 40 E	3									C1, D5		51	3	S	cz
261CV	2 24 N	279 49	Apr 20	8.8		6 07 E	2									C1		22	5	S	c
262CV	2 32 N	280 03	Do.					14.2		24 49 N	3	14.2		.3238	3	D5	EI3,189.1234†	22	4	S	bc
263CV	2 40 N	280 09	Do.	17.8		5 54 E	3									C1		22	3	S	c
264CV	3 07 N	280 32	Apr 21	6.1		5 52 E	3									C1		22	4	S	c
265CV	3 36 N	280 45	Do.					14.2		27 02 N	3	14.2		.3240	3	D5	EI3,189.1234†	11	4	S	bc
266CV	3 47 N	280 49	Do.	17.3		5 43 E	3									C1, D5		11	3	S	bc
267CV	4 29 N	281 18	Apr 22	6.4		5 19 E	3									C1		11	3	S	c
268CV	5 19 N	281 31	Do.					14.3		30 17 N	3	14.3		.3227	3	D5	EI3,189.1234†	354–112	7	MS	qr
269CV	6 40 N	281 41	Apr 23	7.9		4 25 E	2									C1		349	8	M	c
270CV	7 20 N	281 36	Do.					14.4		33 38 N	3	14.4		.3218	3	D5	EI3,189.1234†	340	12	M	or
271CV[1]	7 57 N	280 38	Apr 24	7.1		4 53 E	3									C1		326	11	S	c

CRUISE V, ATLANTIC OCEAN, 1918.

Station	Lat.	Long. East of Gr.	Date	Declination L. M. T.		Declination Value	Declination Wt.	Inclination L. M. T.		Inclination Value	Inclination Wt.	Hor. intensity L. M. T.		Hor. intensity Value	Hor. intensity Wt.	Instruments Compass	Instruments Dip Circle	Remarks Course	Remarks Roll	Remarks Sea	Weather
	° ′	° ′	*1918*	h	h	° ′		h	h	° ′		h	h	c. g. s.				°	°		
272CV	10 30 N	280 29	May 12					13.8		38 19 N	2	13.8		0.3199	2	D5	189.1234†	17	10	R	c
273CV	10 41 N	280 33	Do.	16.8		4 29 E	2									C1, D5		34	7	MLR	c
274CV	11 07 N	280 32	May 13	6.2		4 29 E	3									C1, D5		349	14	ML	bc
275CV	11 59 N	280 24	Do.					14.8		40 21 N	3	14.8		.3177	3	D5	EI3,189.1234†	6	12	MR	bc
276CV	12 11 N	280 25	Do.	17.5		4 18 E	3									C1, D5		11	8	MR	bc
277CV	13 03 N	280 19	May 14	6.2		4 14 E	3									C1, D5		354	12	R	bc
278CV	13 41 N	280 11	Do.					14.4		42 55 N	2	14.3		.3136	2	D5	EI3,189.1234†	0	12	R	bc
279CV	13 54 N	280 07	Do.	17.2		3 59 E	3									C1, D5		349	13	MR	bc
280CV	13 49 N	280 11	May 15	6.2		4 00 E	3									C1, D5		343	12	MR	bc

[1] The *Carnegie* was at Balboa from April 24 to May 1 and at Cristobal from May 3 to May 11. The passage through the Panama Canal was made on May 2.

CRUISE V, ATLANTIC OCEAN, 1918 *Continued.*

	° ′	° ′	*1918*	h	h	° ′		h	h	° ′		h	h	c. g. s.				°	°		
281CV	14 09 N	279 23	May 15	....	....	....	..	14.4	....	43 24 N	3	14.4	....	0.3134	3	D5	EI3,189.1234†	304	10	MS	bc
282CV	14 19 N	279 10	Do.	17.3	....	4 14 E	3	....	....	....	..	....	....	......	..	C1, D5	....	338	8	M	bc
283CV	15 30 N	278 45	May 16	6.0	....	4 35 E	3	....	....	....	..	....	....	......	..	C1, D5	....	338	8	M	bc
284CV	16 12 N	278 24	Do.	....	....	....	..	14.1	....	46 00 N	3	14.1	....	.3098	3	D5	EI3,189.1234†	335	8	MS	bc
285CV	16 27 N	278 16	Do.	17.0	....	4 10 E	3	....	....	....	..	....	....	......	..	C1, D5	....	332	6	MS	bc
286CV	17 34 N	277 40	May 17	6.1	....	4 18 E	3	....	....	....	..	....	....	......	..	C1, D5	....	332	8	S	bc
287CV	18 14 N	277 10	Do.	....	....	....	..	14.3	....	48 32 N	3	14.3	....	.3056	3	D5	EI3,189.1234†	338	7	MS	bc
288CV	18 31 N	277 00	Do.	17.6	....	4 15 E	3	....	....	....	..	....	....	......	..	C1, D5	....	338	6	S	bc
289CV	19 35 N	276 33	May 18	6.1	....	4 34 E	3	....	....	....	..	....	....	......	..	C1, D5	....	304	10	MS	bc
290CV	20 26 N	276 05	Do.	....	....	....	..	14.4	....	51 06 N	3	14.3	....	.3002	3	D5	EI3,189.1234†	315	5	S	bc
291CV	20 40 N	275 53	Do.	17.5	....	4 34 E	3	....	....	....	..	....	....	......	..	C1, D5	....	315	5	S	bc
292CV	21 06 N	275 02	May 19	5.9	....	4 52 E	3	....	....	....	..	....	....	......	..	C1, D5	....	292	5	MS	bc
293CV	21 30 N	274 34	Do.	....	....	....	..	14.4	....	52 05 N	3	14.4	....	.2994	3	D5	EI3,189.1234†	329	8	MS	bc
294CV	21 40 N	274 24	Do.	17.9	....	4 44 E	3	....	....	....	..	....	....	......	..	C1, D5	....	315	7	MS	bc
295CV	22 59 N	273 48	May 20	5.8	....	5 11 E	3	....	....	....	..	....	....	......	..	C1, D5	....	354	5	MS	bc
296CV	23 48 N	273 43	Do.	....	....	....	..	14.1	....	54 47 N	3	14.1	....	.2900	3	D5	EI3,189.1234†	343	7	MS	bc
297CV	23 49 N	273 50	Do.	17.9	....	4 37 E	3	....	....	....	..	....	....	......	..	C1, D5	....	135	3	MS	bc
298CV	23 15 N	274 28	May 21	6.1	....	5 01 E	3	....	....	....	..	....	....	......	..	C1, D5	....	17	7	MS	bc
299CV	24 04 N	274 44	Do.	....	....	....	..	14.5	....	55 14 N	2	14.5	....	.2861	2	D5	EI3,189.1234†	3	8	MR	bc
300CV	24 19 N	274 40	Do.	17.6	....	4 42 E	3	....	....	....	..	....	....	......	..	C1, D5	....	357	10	M	bc
301CV	23 44 N	275 44	May 22	6.0	....	4 23 E	3	....	....	....	..	....	....	......	..	C1, D5	....	129	6	MR	bc
302CV	23 33 N	276 12	Do.	....	....	....	..	14.4	....	55 10 N	2	14.3	....	.2878	2	D5	EI3,189.1234†	335	12	MR	bc
303CV	23 50 N	276 11	Do.	17.5	....	4 08 E	2	....	....	....	..	....	....	......	..	C1	....	352	8	R	o
304CV	23 37 N	277 02	May 23	5.7	....	3 56 E	2	....	....	....	..	....	....	......	..	C1	....	17	5	R	oc
305CV	23 53 N	277 10	Do.	....	....	....	..	14.4	....	55 43 N	2	14.4	....	.2834	3	D5	EI3,189.1234†	127	9	MR	bc
306CV	23 37 N	277 27	Do.	17.8	....	3 08 E	2	....	....	....	..	....	....	......	..	C1	....	146	12	R	oq
307CV	23 40 N	278 21	May 24	....	....	....	..	14.6	....	55 32 N	2	14.6	....	.2830	2	D5	EI3,189.1234†	138	20	R	bc
308CV	23 48 N	278 28	Do.	17.5	....	3 02 E	2	....	....	....	..	....	....	......	..	C1, D5	....	349	14	R	o
309CV	24 27 N	279 17	May 25	....	....	....	..	13.8	....	56 44 N	2	13.8	....	.2785	3	D5	189.1234†	28	8	MR	oqr
310CV	24 44 N	279 25	Do.	17.0	....	2 30 E	2	....	....	....	..	....	....	......	..	C1	....	28	16	MR	o
311CV	25 04 N	280 00	May 26	6.4	....	2 11 E	2	....	....	....	..	....	....	......	..	C1	....	158	8	M	o
312CV	25 35 N	280 11	Do.	....	....	....	..	13.6	....	58 10 N	3	13.6	....	.2720	3	D5	189.1234†	3	10	M	bc
313CV	26 10 N	280 13	Do.	17.8	....	1 31 E	3	....	....	....	..	....	....	......	..	C1, D5	....	17	5	M	bc
314CV	28 11 N	280 16	May 27	6.4	....	0 43 E	3	....	....	....	..	....	....	......	..	C1, D5	....	6	8	MS	bc
315CV	29 01 N	280 08	Do.	....	....	....	..	14.6	....	61 52 N	3	14.5	....	.2544	3	D5	EI3,189.1234†	158,22	6	MS	bc
316CV	29 25 N	280 10	Do.	17.5	....	0 22 E	3	....	....	....	..	....	....	......	..	C1, D5	....	20	7	MS	o
317CV	30 26 N	280 49	May 28	5.6	....	0 07 W	3	....	....	....	..	....	....	......	..	C1, D5	....	45	6	S	bc
318CV	30 44 N	281 03	Do.	....	....	....	..	14.7	....	63 34 N	3	14.7	....	.2435	3	D5	EI3,189.1234†	34	8	S	bc
319CV	30 50 N	281 10	Do.	17.8	....	0 59 W	3	....	....	....	..	....	....	......	..	C1, D5	....	68	5	S	bc
320CV	31 09 N	281 41	May 29	5.7	....	1 22 W	3	....	....	....	..	....	....	......	..	C1, D5	....	22	5	S	bc
321CV	31 14 N	281 52	Do.	....	....	....	..	14.5	....	63 47 N	3	14.5	....	.2418	3	D5	EI3,189.1234†	135–45	6	S	bc
322CV	31 18 N	281 55	Do.	17.8	....	1 22 W	3	....	....	....	..	....	....	......	..	C1, D5	....	56	7	S	bc
323CV	31 42 N	282 05	May 30	5.8	....	1 19 W	3	....	....	....	..	....	....	......	..	C1, D5	....	56	8	S	bc
324CV	31 54 N	282 22	Do.	....	....	....	..	14.6	....	64 51 N	3	14.2	....	.2346	3	D5	EI3,189.1234†	56	9	S	bc
325CV	32 00 N	282 32	Do.	17.8	....	2 02 W	3	....	....	....	..	....	....	......	..	C1, D5	....	56	5	S	bc
326CV	32 28 N	283 24	May 31	5.6	....	2 50 W	3	....	....	....	..	....	....	......	..	C1, D5	....	56	7	S	bc
327CV	32 52 N	284 15	Do.	....	....	....	..	14.4	....	65 29 N	3	14.4	....	.2298	3	D5	EI3,189.1234†	56	8	MS	bc
328CV	33 01 N	284 33	Do.	17.8	....	4 25 W	3	....	....	....	..	....	....	......	..	C1, D5	....	56	8	MS	bc
329CV	33 43 N	285 16	Jun 1	5.6	....	4 51 W	3	....	....	....	..	....	....	......	..	C1, D5	....	45	8	MSL	bcs
330CV	33 54 N	285 39	Do.	....	....	....	..	14.7	....	66 40 N	3	14.7	....	.2209	3	D5	EI3,189.1234†	219	7	SL	bcs
331CV	33 54 N	285 43	Do.	17.9	....	5 25 W	3	....	....	....	..	....	....	......	..	C1, D5	....	45	9	SL	bcs
332CV	34 08 N	286 07	Jun 2	5.8	....	5 36 W	3	....	....	....	..	....	....	......	..	C1, D5	....	34	7	SL	bcs
333CV	34 46 N	285 51	Do.	....	....	....	..	14.2	....	67 22 N	3	14.2	....	.2162	3	D5	EI3,189.1234†	340	7	MS	bc
334CV	35 10 N	285 46	Do.	17.7	....	6 16 W	3	....	....	....	..	....	....	......	..	C1, D5	....	338	7	MS	bcs
335CV	36 02 N	285 29	Jun 3	5.6	....	6 52 W	3	....	....	....	..	....	....	......	..	C1, D5	....	326	5	SL	bcs
336CV	36 07 N	285 04	Do.	....	....	....	..	13.6	....	68 26 N	3	13.6	....	.2091	3	D5	189.1234†	315	4	S	cs
337CV	36 09 N	284 49	Do.	17.8	....	5 42 W	2	....	....	....	..	....	....	......	..	C1, D5	....	309	6	S	cs
338CV	36 11 N	284 34	Jun 4	5.8	....	5 49 W	3	....	....	....	..	....	....	......	..	C1, D5	....	315	4	S	bcs

FINAL RESULTS OF OCEAN MAGNETIC OBSERVATIONS ON THE CARNEGIE, 1915–1921—*Continued.*

CRUISE V, ATLANTIC OCEAN, 1918 *Concluded.*

Station	Lat.	Long. East of Gr.	Date	Declination L. M. T.	Declination Value	Wt.	Inclination L. M. T.	Inclination Value	Wt.	Hor. intensity L. M. T.	Hor. intensity Value	Wt.	Instruments Compass	Instruments Dip Circle	Remarks Course	Remarks Roll	Remarks Sea	Weather
	° ′	° ′	*1918*	h h	° ′		h h	° ′		h h	c. g. s.				°	°		
339CV[1]	37 19 N	283 51	Jun 8	18.0	6 13 W	3	....	....	..	....	......	..	C1	....	11	0	S	bc
340CV[2]	38 12 N	283 44	Jun 9	5.1 to 7.2	6 14 W	3	....	....	..	....	......	..	C1, D5	....	Swing	0	S	bc
341CV[2]	38 13 N	283 44	Do.	....	....	..	8.3 to 12.2	70 13 N	3	8.3 to 12.2	0.1964	3	D5	189.34	Swing	0–1	S	bc
342CV[3]	38 14 N	283 07	Jun 10	5.4	5 58 W	3	....	....	..	....	......	..	C1, D5	....	295	1	S	bc
CRUISE VI, ATLANTIC OCEAN, 1919–1920.																		
	° ′	° ′	*1919*	h h	° ′		h h	° ′		h h	c. g. s.				°	°		
0CVI[4]	38 12 N	283 44	Oct 11	....	....	..	7.7 to 12.1	70 14 N	3	7.7 to 12.1	0.1950	3	D5	189.34	Swing	0–1	S	b
0aCVI[4]	38 18 N	283 42	Do.	15.0 to 17.3	6 29 W	3	....	....	..	....	......	..	C1, D5	....	Swing	0–1	S	b
1CVI	38 04 N	283 45	Oct 14	17.0	6 26 W	3	....	....	..	....	......	..	C1, D5	....	180	..	S	bc
2CVI[5]	37 12 N	283 52	Oct 15	7.9	6 11 W	3	....	....	..	....	......	..	C1, D5	....	270	2	S	b
3CVI	36 45 N	284 23	Oct 19	16.4	6 13 W	3	....	....	..	....	......	..	C1, D5	....	135	4	M	bc
4CVI	36 03 N	285 40	Oct 20	6.6	6 29 W	3	....	....	..	....	......	..	C1, D5	....	124	6	M	bc
5CVI	35 40 N	286 20	Do.	....	....	..	14.2	68 15 N	2	14.2	.2091	2	D5	189.1234†	39	16	MR	crq
6CVI	36 32 N	286 44	Oct 21	7.8	8 06 W	2	....	....	..	....	......	..	C1, D5	....	0	16	M	bc
7CVI	37 01 N	287 34	Do.	....	....	..	14.0	69 40 N	1	14.0	.1998	1	D5	189.134†	68	32	R	oqr
8CVI	38 03 N	290 39	Oct 22	6.7	12 11 W	2	....	....	..	....	......	..	C1, D5	....	79	15	MR	bc
9CVI	38 30 N	291 58	Do.	....	....	..	14.1	70 24 N	2	14.2	.1897	2	D5	189.1234†	79	10	M	o
10CVI	38 38 N	295 20	Oct 23	8.2	16 05 W	2	....	....	..	....	......	..	C1	....	169	7	M	o
11CVI	38 24 N	295 54	Do.	....	....	..	15.1	69 49 N	3	15.0	.1925	3	D5	EI7,189.234†	135–158	8	M	o
12CVI	38 21 N	296 00	Do.	15.9	16 05 W	2	....	....	..	....	......	..	C1	....	124	8	M	bc
13CVI	38 04 N	297 35	Oct 24	....	....	..	14.8	69 32 N	3	14.8	.1955	3	D5	EI7,189.1234†	22	7	M	o
14CVI	37 05 N	297 58	Oct 25	7.4	16 31 W	3	....	....	..	....	......	..	C1, D5	....	169	6	M	bc
15CVI	36 52 N	298 01	Do.	....	....	..	14.1	68 35 N	2	14.2	.2000	2	D5	189.1234†	45	13	MR	c
16CVI	38 25 N	298 54	Oct 26	7.2	17 11 W	3	....	....	..	....	......	..	C1, D5	....	22	11	M	bc
17CVI	39 01 N	299 06	Do.	16.1	18 28 W	3	....	....	..	....	......	..	C1, D5	....	45	11	M	bc
18CVI	39 20 N	301 49	Oct 27	7.6	20 20 W	2	....	....	..	....	......	..	C1	....	112	10	M	bc
19CVI	39 18 N	303 11	Do.	....	....	..	14.5	69 25 N	2	14.5	.1911	2	D5	189.1234†	112	10	M	or
20CVI	39 04 N	305 56	Oct 28	8.5	22 10 W	2	....	....	..	....	......	..	C1, D5	....	169	9	M	c
21CVI	38 39 N	306 49	Do.	....	....	..	14.5	67 58 N	3	14.5	.1981	3	D5	189.1234†	135	8	S	bc
22CVI	38 27 N	307 01	Do.	16.3	22 14 W	3	....	....	..	....	......	..	C1, D5	....	163	13	M	bc
23CVI	38 24 N	308 18	Oct 29	7.0	22 28 W	3	....	....	..	....	......	..	C1, D5	....	79	14	M	bc
24CVI	38 30 N	309 55	Do.	....	....	..	14.8	67 20 N	3	14.8	.1999	3	D5	EI7,189.1234†	101	11	M	bc
25CVI	38 35 N	310 24	Do.	16.8	23 01 W	2	....	....	..	....	......	..	C1	....	101	18	L	bc
26CVI	38 50 N	313 43	Oct 30	8.7	23 42 W	1	....	....	..	....	......	..	C1, D5	....	101	32	R	bc
27CVI	38 54 N	314 41	Do.	....	....	..	14.2	66 15 N	2	14.2	.2053	2	D5	189.1234†	101	15	R	c
28CVI[6]	38 29 N	316 17	Nov 1	7.2	24 01 W	1	....	....	..	....	......	..	C1, D5	....	45	22	LR	bc
29CVI	38 25 N	316 39	Do.	....	....	..	13.9	65 28 N	1	13.8	.2075	1	D5	189.1234†	101	25	R	bc
30CVI	38 25 N	316 54	Do.	15.8	24 32 W	1	....	....	..	....	......	..	C1, D5	....	112	20	R	bc
31CVI	38 26 N	319 00	Nov 2	8.1	23 56 W	2	....	....	..	....	......	..	C1	....	56	14	L	bc
32CVI	38 28 N	319 46	Do.	....	....	..	14.0	64 28 N	3	14.0	.2109	3	D5	189.1234†	112	14	SL	c
33CVI	38 27 N	320 02	Do.	15.8	24 13 W	3	....	....	..	....	......	..	C1, D5	....	135	20	ML	bc
34CVI	38 39 N	321 57	Nov 3	....	....	..	14.6	63 57 N	3	14.5	.2124	3	D5	EI7,189.1234†	68	13	ML	or
35CVI	39 15 N	322 30	Nov 4	7.2	24 22 W	3	....	....	..	....	......	..	C1, D5	....	158	7	M	bc

[1] In Chesapeake Bay. [2] Swinging ship in Chesapeake Bay. [3] On the Potomac River. [4] Swinging ship in Chesapeake Bay.
[5] From October 16 to October 18 the *Carnegie* was at Old Point Comfort, Virginia. [6] Hove to in a gale.

CRUISE VI, ATLANTIC OCEAN, 1919–1920—*Continued.*

	° ′	° ′	*1919*	h	h	° ′		h	h	° ′		h	h	c.g.s.				°	°		
36CVI	39 05 N	323 34	Nov 4	....	....	....	..	14.2	....	63 49 N	2	14.2	....	0.2120	2	D5	189.1234†	112	12	M	bc
37CVI	39 06 N	323 58	Do.	16.0	....	24 12 W	3	....	....	....	..	....	....	......	..	C1, D5	....	112	15	M	bc
38CVI	38 57 N	326 47	Nov 5	7.4	....	23 42 W	3	....	....	....	..	....	....	......	..	C1, D5	....	112	15	M	bc
39CVI	38 53 N	327 47	Do.	....	....	....	..	13.8	....	62 52 N	2	13.8	....	.2154	2	D5	189.1234†	112	9	M	bc
40CVI	38 53 N	328 07	Do.	15.9	....	23 04 W	3	....	....	....	..	....	....	......	..	C1, D5	....	112	9	ML	bc
41CVI	38 48 N	329 18	Nov 6	8.0	....	22 43 W	3	....	....	....	..	....	....	......	..	C1, D5	....	112	20	L	bc
42CVI	38 45 N	329 33	Do.	....	....	....	..	13.9	....	61 52 N	3	13.9	....	.2195	3	D5	189.1234†	112	14	ML	bc
43CVI	37 30 N	329 46	Nov 7	8.5	....	22 19 W	2	....	....	....	..	....	....	......	..	C1	....	202	8	MR	o
44CVI	37 02 N	329 51	Do.	....	....	....	..	14.0	....	60 38 N	2	14.0	....	.2264	2	D5	189.1234†	180	21	R	o
45CVI	36 52 N	329 52	Do.	15.6	....	21 58 W	2	....	....	....	..	....	....	......	..	C1, D5	....	180	19	MC	bc
46CVI	35 52 N	329 58	Nov 8	7.1	....	21 38 W	3	....	....	....	..	....	....	......	..	C1, D5	....	236	7	L	bc
47CVI	35 37 N	329 44	Do.	....	....	....	..	14.0	....	59 25 N	3	14.0	....	.2315	3	D5	189.1234†	90	5	S	bc
48CVI	35 39 N	331 37	Nov 9	8.9	....	20 59 W	3	....	....	....	..	....	....	......	..	C1, D5	....	101	6	M	o
49CVI	35 35 N	332 08	Do.	....	....	....	..	13.8	....	58 44 N	3	13.8	....	.2328	3	D5	189.1234†	124	12	M	o
50CVI	35 14 N	333 59	Nov 10	9.9	....	20 46 W	2	....	....	....	..	....	....	......	..	C1	....	84	6	S	o
51CVI	35 08 N	334 17	Do.	....	....	....	..	13.9	....	57 45 N	3	13.9	....	.2359	3	D5	189.1234†	124	4	S	b
52CVI	35 05 N	334 29	Do.	15.6	....	20 23 W	3	....	....	....	..	....	....	......	..	C1, D5	....	124	4	S	bc
53CVI	34 21 N	335 34	Nov 11	8.1	....	20 10 W	3	....	....	....	..	....	....	......	..	C1, D5	....	186	7	S	bc
54CVI	34 09 N	335 58	Do.	....	....	....	..	13.8	....	56 16 N	3	13.8	....	.2410	3	D5	189.1234†	146	14	SM	bc
55CVI	34 02 N	336 11	Do.	16.1	....	19 51 W	3	....	....	....	..	....	....	......	..	C1, D5	....	146	12	M	bc
56CVI	32 48 N	338 16	Nov 12	....	....	....	..	13.8	....	54 21 N	3	13.8	....	.2490	3	D5	189.1234†	169	12	M	orq
57CVI	30 39 N	340 07	Nov 13	8.8	....	18 04 W	2	....	....	....	..	....	....	......	..	C1, D5	....	214	18	R	o
58CVI	30 02 N	340 18	Do.	....	....	....	..	13.7	....	50 17 N	1	13.7	....	.2637	1	D5	189.1234†	191	21	R	bc
59CVI	29 43 N	340 23	Do.	16.2	....	17 59 W	2	....	....	....	..	....	....	......	..	C1, D5	....	191	22	R	bc
60CVI	27 54 N	340 42	Nov 14	7.0	....	17 46 W	3	....	....	....	..	....	....	......	..	C1, D5	....	202	10	LM	bc
61CVI	27 08 N	340 47	Do.	....	....	....	..	14.0	....	45 06 N	3	14.0	....	.2756	3	D5	189.1234†	202	10	LM	b
62CVI	26 58 N	340 49	Do.	16.0	....	17 55 W	3	....	....	....	..	....	....	......	..	C1, D5	....	202	14	SL	bc
63CVI	25 50 N	340 39	Nov 15	8.4	....	17 40 W	3	....	....	....	..	....	....	......	..	C1, D5	....	214	9	SL	bc
64CVI	25 30 N	340 32	Do.	....	....	....	..	13.9	....	44 29 N	3	13.9	....	.2788	3	D5	189.1234†	214	13	SL	b
65CVI	25 25 N	340 30	Do.	16.1	....	17 40 W	3	....	....	....	..	....	....	......	..	C1, D5	....	174	10	SL	bc
66CVI	25 03 N	340 04	Nov 16	7.8	....	18 09 W	3	....	....	....	..	....	....	......	..	C1, D5	....	259	10	M	o
67CVI	25 03 N	340 32	Nov 17	8.0	....	17 43 W	3	....	....	....	..	....	....	......	..	C1, D5	....	236,202	10	S	o
68CVI	24 35 N	340 26	Do.	....	....	....	..	14.0	....	43 17 N	3	14.0	....	.2824	3	D5	189.1234†	202	4	M	oqr
69CVI	22 32 N	340 19	Nov 18	7.4	....	18 04 W	3	....	....	....	..	....	....	......	..	C1	....	191	9	M	o
70CVI	21 44 N	340 28	Do.	....	....	....	..	13.9	....	38 47 N	2	13.9	....	.2922	2	D5	189.1234†	180	10	M	bc
71CVI	21 30 N	340 32	Do.	16.2	....	18 06 W	3	....	....	....	..	....	....	......	..	C1, D5	....	180	8	M	bc
72CVI	19 39 N	340 01	Nov 19	7.1	....	18 41 W	2	....	....	....	..	....	....	......	..	C1	....	180	10	M	bcs
73CVI	18 56 N	341 09	Do.	....	....	....	..	14.0	....	33 59 N	1	14.0	....	.2993	2	D5	189.1234†	174	11	M	bcs
74CVI	18 42 N	341 13	Do.	16.4	....	18 16 W	2	....	....	....	..	....	....	......	..	C1	....	174	9	M	s
75CVI	16 59 N	341 49	Nov 20	7.0	....	18 15 W	2	....	....	....	..	....	....	......	..	C1	....	174	10	M	s
76CVI	16 23 N	341 55	Do.	....	....	....	..	13.8	....	29 25 N	3	13.8	....	.3050	3	D5	189.1234†	180	11	M	s
77CVI	16 11 N	342 00	Do.	16.6	....	18 16 W	3	....	....	....	..	....	....	......	..	C1	....	174	11	M	s
78CVI	15 12 N	342 25	Nov 21	7.3	....	18 22 W	3	....	....	....	..	....	....	......	..	C1	....	174	6	S	s
79CVI	14 59 N	342 29	Do.	....	....	....	..	13.9	....	26 07 N	3	13.9	....	.3089	3	D5	189.1234†	197	4	MS	s
80CVI[1]	14 53 N	342 28	Nov 22	7.1	....	18 28 W	3	....	....	....	..	....	....	......	..	C1	....	146	7	S	s
81CVI	13 06 N	342 25	Nov 27	6.7	....	18 35 W	3	....	....	....	..	....	....	......	..	C1, D5	....	202	10	S	bc
82CVI	12 27 N	342 24	Do.	....	....	....	..	14.6	....	21 40 N	3	14.6	....	.3114	3	D5	189.1234†	191	12	S	bc
83CVI	12 13 N	342 25	Do.	17.0	....	18 44 W	3	....	....	....	..	....	....	......	..	C1, D5	....	191	8	SM	b
84CVI	11 01 N	342 38	Nov 28	6.6	....	18 56 W	3	....	....	....	..	....	....	......	..	C1, D5	....	169	5	SM	b
85CVI	10 15 N	343 19	Do.	....	....	....	..	14.2	....	17 02 N	3	14.2	....	.3099	3	D5	189.1234†	152	4	S	bc
86CVI	10 08 N	343 25	Do.	15.9	....	19 10 W	2	....	....	....	..	....	....	......	..	C1	....	152	4	S	o
87CVI	9 37 N	343 46	Nov 29	7.0	....	18 59 W	3	....	....	....	..	....	....	......	..	C1	....	174	6	S	bc
88CVI	9 24 N	343 55	Do.	....	....	....	..	14.4	....	14 43 N	3	14.4	....	.3106	3	D5	189.1234†	158	10	S	bc
89CVI	8 50 N	344 33	Nov 30	6.6	....	19 01 W	3	....	....	....	..	....	....	......	..	C1	....	174	12	S	bc
90CVI	7 54 N	345 40	Dec 1	6.8	....	18 47 W	3	....	....	....	..	....	....	......	..	C1, D5	....	146	2	S	bcs
91CVI	7 39 N	345 55	Do.	....	....	....	..	14.2	....	9 31 N	3	14.2	....	.3124	3	D5	189.1234†	146	6	S	bc
92CVI	7 38 N	346 02	Do.	16.7	....	18 58 W	3	....	....	....	..	....	....	......	..	C1, D5	....	135	6	S	bc
93CVI	7 20 N	346 35	Dec 2	6.6	...	18 37 W	3	....	....	....	..	....	....	......	..	C1, D5	....	152	5	S	bcs

[1] From November 23 to November 26 the *Carnegie* was at Dakar, Senegal, French West Africa.

FINAL RESULTS OF OCEAN MAGNETIC OBSERVATIONS ON THE CARNEGIE, 1915–1921—*Continued.*

CRUISE VI, ATLANTIC OCEAN, 1919–1920—*Continued.*

Station	Lat.	Long. East of Gr.	Date	Declination L. M. T.		Declination Value	Wt.	Inclination L. M. T.		Inclination Value	Wt.	Hor. intensity L. M. T.		Hor. intensity Value	Wt.	Instruments Compass	Instruments Dip Circle	Remarks Course	Remarks Roll	Remarks Sea	Weather
	° ′	° ′	*1919*	*h*	*h*	° ′		*h*	*h*	° ′		*h*	*h*	*c. g. s.*				°	°		
94CVI	6 46 N	346 33	Dec 3	7.0	....	18 45 W	3	....	....	....	..	....	....	......	..	C1, D5	....	191	8	SL	bc
95CVI	6 30 N	346 37	Dec 4	6.6	....	18 50 W	3	....	....	....	..	....	....	......	..	C1, D5	....	169	6	MS	bc
96CVI	6 18 N	347 00	Do.	....	....	....	..	14.6	....	5 27 N	3	14.6	....	0.3097	3	D5	189.1234†	135	11	S	bc
97CVI	5 53 N	348 12	Dec 5	....	....	....	..	14.2	....	3 31 N	2	14.2	....	.3076	3	D5	189.1234†	135	3	S	bc
98CVI	5 48 N	348 20	Do.	16.2	....	18 25 W	3	....	....	....	..	....	....	......	..	C1, D5	....	146	6	SM	bc
99CVI	5 11 N	349 18	Dec 6	....	....	....	..	14.2	....	1 11 N	3	14.2	....	.3061	3	D5	189.1234†	146	10	S	bc
100CVI	5 08 N	349 17	Do.	15.8	....	18 32 W	2	....	....	....	..	....	....	......	..	C1, D5	....	146	10	MS	bc
101CVI	4 51 N	350 13	Dec 7	7.8	....	18 14 W	3	....	....	....	..	....	....	......	..	C1, D5	....	124	8	MS	bc
102CVI	4 48 N	350 40	Do.	....	....	....	..	14.2	....	1 04 S	3	14.2	....	.3049	3	D5	189.1234†	124–135	9	S	bc
103CVI	4 45 N	350 50	Do.	16.9	....	18 04 W	3	....	....	....	..	....	....	......	..	C1, D5	....	135	8	MS	bc
104CVI	4 22 N	351 33	Dec 8	6.6	....	17 59 W	3	....	....	....	..	....	....	......	..	C1, D5	....	146	7	S	bc
105CVI	4 20 N	352 04	Do.	....	...	....	..	14.2	....	2 58 S	3	14.2	....	.3056	3	D5	189.1234†	112	8	M	bc
106CVI	4 17 N	352 17	Do.	16.8	....	17 20 W	3	....	....	....	..	....	....	......	..	C1, D5	....	135	4	S	bc
107CVI	3 38 N	351 58	Dec 9	6.6	....	17 49 W	3	....	....	....	..	....	....	......	..	C1, D5	....	112	6	MS	bc
108CVI	3 41 N	352 28	Do.	....	....	....	..	14.2	....	4 25 S	3	14.2	....	.3036	3	D5	189.1234†	110	6	S	bc
109CVI	3 44 N	352 42	Do.	16.8	....	17 31 W	3	....	....	....	..	....	....	......	..	C1, D5	....	101	5	MS	bc
110CVI	4 01 N	353 46	Dec 10	6.8	....	16 58 W	3	....	....	....	..	....	....	......	..	C1, D5	....	68	9	MS	bcq
111CVI	4 07 N	354 29	Do.	....	....	....	..	14.3	....	4 58 S	3	14.2	....	.3043	3	D5	189.1234†	107	7	S	bc
112CVI	4 08 N	354 40	Do.	16.9	....	16 43 W	3	....	....	....	..	....	....	......	..	C1, D5	....	115	10	MS	bc
113CVI	4 05 N	355 28	Dec 11	16.9	....	16 23 W	3	....	....	....	..	....	....	......	..	C1, D5	....	146	7	SL	bc
114CVI	4 10 N	356 08	Dec 12	6.6	....	16 08 W	2	....	....	....	..	....	....	......	..	C1	....	90	6	S	bc
115CVI	3 57 N	356 22	Do.	....	....	....	..	14.2	....	6 27 S	3	14.2	....	.3036	3	D5	189.1234†	158	3	S	bc
116CVI	3 51 N	356 33	Do.	16.9	....	16 02 W	3	....	....	....	..	....	....	......	..	C1, D5	....	135	4	MS	bc
117CVI	3 37 N	357 36	Dec 13	6.8	....	15 43 W	2	....	....	....	..	....	....	......	..	C1	....	68	8	S	bc
118CVI	3 31 N	358 15	Do.	....	....	....	..	14.3	....	8 52 S	3	14.3	....	.3035	3	D5	189.1234†	135	6	S	bc
119CVI	3 25 N	358 26	Do.	16.8	....	15 25 W	3	....	....	....	..	....	....	......	..	C1, D5	....	141	5	S	bc
120CVI	2 51 N	359 29	Dec 14	....	....	....	..	14.5	....	10 51 S	3	14.5	....	.3009	3	D5	189.1234†	146	4	S	bc
121CVI	2 46 N	359 34	Do.	16.5	....	15 12 W	2	....	....	....	..	....	....	......	..	C1	....	158	4	MS	c
122CVI	2 14 N	0 05	Dec 15	7.0	....	15 12 W	3	....	....	....	..	....	....	......	..	C1, D5	....	174	4	S	bc
123CVI	1 48 N	0 29	Do.	....	....	....	..	14.3	....	13 44 S	3	14.3	....	.2972	3	D5	189.1234†	158	5	S	c
124CVI	1 38 N	0 36	Do.	17.0	....	15 04 W	3	....	....	....	..	....	....	......	..	C1, D5	....	169	5	S	bc
125CVI	1 11 N	1 21	Dec 16	6.6	....	15 07 W	3	....	....	....	..	....	....	......	..	C1, D5	....	68	6	S	bc
126CVI	0 52 N	1 53	Do.	....	....	....	..	14.3	....	16 17 S	2	14.3	....	.2941	2	D5	189.1234†	141	5	S	bc
127CVI	0 44 N	2 07	Do.	17.2	....	14 59 W	2	....	....	....	..	....	....	......	..	C1	....	138	8	M	bc
128CVI	0 12 N	3 22	Dec 17	6.9	....	14 38 W	2	....	....	....	..	....	....	......	..	C1	....	110	9	M	bc
129CVI	0 06 S	3 58	Do.	....	....	....	..	14.0	....	19 14 S	3	14.0	....	.2921	3	D5	189.1234†	146	5	M	bc
130CVI	0 18 S	4 10	Do.	17.4	....	14 22 W	2	....	....	....	..	....	....	......	..	C1	....	163	6	M	bc
131CVI	1 23 S	4 50	Dec 18	....	....	....	..	14.5	....	22 08 S	3	14.5	....	.2861	3	D5	189.1234†	315	5	M	c
132CVI	0 57 S	3 44	Dec 19	7.2	....	14 58 W	3	....	....	....	..	....	....	......	..	C1, D5	....	298	7	MS	c
133CVI	0 37 S	3 25	Do.	....	....	....	..	14.4	....	19 40 S	3	14.4	....	.2889	3	D5	189.1234†	326	4	S	c
134CVI	0 23 S	3 23	Dec 20	6.6	....	14 40 W	3	....	....	....	..	....	....	......	..	C1, D5	....	276	6	S	bc
135CVI	0 18 S	3 00	Do.	....	....	....	..	14.4	....	19 11 S	3	14.4	....	.2897	3	D5	189.1234†	284	6	S	bc
136CVI	0 17 S	2 53	Do.	17.3	....	14 47 W	3	....	....	....	..	....	....	......	..	C1, D5	....	281	4	S	bc
137CVI	0 26 S	1 54	Dec 21	7.1	....	15 34 W	3	....	....	....	..	....	....	......	..	C1, D5	....	264	6	S	c
138CVI	0 34 S	1 20	Do.	....	....	....	..	14.3	....	19 02 S	3	14.3	....	.2893	3	D5	189.1234†	267	7	M	bc
139CVI	0 38 S	1 08	Do.	17.0	....	15 44 W	3	....	....	....	..	....	....	......	..	C1, D5	....	264	7	MS	bc
140CVI	1 07 S	0 16	Dec 22	6.8	....	16 22 W	3	....	....	....	..	....	....	......	..	C1, D5	....	242	6	S	bc
141CVI	1 19 S	359 55	Do.	....	....	....	..	14.4	....	19 33 S	3	14.4	....	.2851	3	D5	189.1234†	248	4	S	bc
142CVI	1 26 S	359 41	Do.	17.2	....	16 41 W	3	....	....	....	..	....	....	......	..	C1, D5	....	281	4	S	bc

CRUISE VI, ATLANTIC OCEAN, 1919–1920—*Continued.*

	° ′	° ′	1919	h	h	° ′		h	h	° ′		h	h	c.g.s.				°	°		
143CVI	1 45 S	358 28	Dec 23	6.6	....	17 27 W	3	....	....	....	..	....	....	......	..	C1, D5	....	264	5	S	bc
144CVI	2 05 S	357 47	Do.	....	....	....	..	14.2	....	19 39 S	2	14.2	....	0.2817	3	D5	189.1234†	248	6	M	bc
145CVI	2 16 S	357 29	Do.	17.2	....	17 49 W	3	....	....	....	..	....	....	......	..	C1, D5	....	281	7	M	bc
146CVI	3 01 S	356 16	Dec 24	7.0	....	18 41 W	3	....	....	....	..	....	....	......	..	C1, D5	....	248	6	M	bc
147CVI	3 29 S	355 36	Do.	....	....	....	..	14.4	....	20 47 S	1	14.4	....	.2762	2	D5	189.1234†	248	5	M	c
148CVI	3 38 S	355 21	Do.	16.9	....	19 27 W	2	....	....	....	..	....	....	......	..	C1, D5	....	284	7	M	bc
149CVI	4 32 S	354 01	Dec 25	6.4	....	20 11 W	3	....	....	....	..	....	....	......	..	C1, D5	....	253	8	M	bc
150CVI	5 00 S	353 16	Do.	....	....	....	..	13.9	....	21 31 S	2	14.0	....	.2702	2	D5	189.234	259	12	M	bc
151CVI	5 13 S	352 53	Do.	17.1	....	20 41 W	3	....	....	....	..	....	....	......	..	C1, D5	....	292	12	M	bc
152CVI	6 35 S	351 27	Dec 26	8.2	....	21 19 W	2	....	....	....	..	....	....	......	..	C1	....	248	12	MR	bc
153CVI	7 06 S	350 55	Do.	....	....	....	..	14.4	....	23 20 S	2	14.4	....	.2533	2	D5	189.1234†	248	8	M	c
154CVI	8 38 S	349 20	Dec 27	7.0	....	22 55 W	2	....	....	....	..	....	....	......	..	C1, D5	....	256	10	M	c
155CVI	9 18 S	348 42	Do.	....	....	....	..	14.3	....	24 17 S	2	14.2	....	.2559	2	D5	189.1234†	242	15	M	c
156CVI	9 51 S	348 10	Do.	20.3	....	23 16 W	2	....	....	....	..	....	....	......	..	C1	....	242	12	M	bc
157CVI	10 47 S	347 01	Dec 28	8.5	....	23 25 W	2	....	....	....	..	....	....	......	..	C1	....	248	12	M	c
158CVI	11 18 S	346 25	Do.	....	....	....	..	14.6	....	25 10 S	2	14.6	....	.2506	2	D5	189.1234†	248	8	M	bc
159CVI	11 31 S	346 12	Do.	17.2	....	23 54 W	3	....	....	....	..	....	....	......	..	C1, D5	....	292	10	M	bc
160CVI	12 35 S	345 02	Dec 29	6.1	....	23 44 W	3	....	....	....	..	....	....	......	..	C1, D5	....	242	15	MS	bc
161CVI	13 16 S	344 15	Do.	....	....	....	..	14.3	....	25 49 S	3	14.2	....	.2459	3	D5	189.1234†	242	8	M	bc
162CVI	13 32 S	343 59	Do.	17.2	....	24 08 W	3	....	....	....	..	....	....	......	..	C1, D5	....	295	8	MS	bc
163CVI	14 38 S	342 51	Dec 30	5.9	....	23 57 W	3	....	....	....	..	....	....	......	..	C1, D5	....	242	8	S	bc
164CVI	15 31 S	342 00	Do.	....	....	....	..	14.6	....	26 23 S	3	14.6	....	.2406	3	D5	189.1234†	242	7	S	b
165CVI	15 44 S	341 47	Do.	17.6	....	23 59 W	3	....	....	....	..	....	....	......	..	C1, D5	....	197	8	MS	bc
166CVI	16 50 S	340 42	Dec 31	5.8	....	23 44 W	3	....	....	....	..	....	....	......	..	C1, D5	....	242	7	MS	bc
167CVI	17 38 S	339 55	Do.	....	....	....	..	14.3	....	27 05 S	3	14.3	....	.2370	3	D5	189.1234†	242	6	S	b
168CVI	17 54 S	339 39	Do.	18.2	....	23 44 W	2	....	....	....	..	....	....	......	..	C1	....	242	6	S	bc
			1920																		
169CVI	18 47 S	338 48	Jan 1	6.9	....	23 17 W	3	....	....	....	..	....	....	......	..	C1, D5	....	242	6	S	bc
170CVI	19 20 S	338 17	Do.	....	....	....	..	14.1	....	27 48 S	2	14.1	....	.2339	2	D5	189.234	242	4	M	c
171CVI	19 30 S	338 06	Do.	17.7	....	23 15 W	2	....	....	....	..	....	....	......	..	C1	....	242	5	S	bc
172CVI	20 12 S	337 23	Jan 2	5.9	....	22 58 W	3	....	....	....	..	....	....	......	..	C1, D5	....	242	6	MS	bc
173CVI	20 48 S	336 46	Do.	....	....	....	..	14.3	....	28 17 S	3	14.3	....	.2312	3	D5	189.1234†	242	10	S	bc
174CVI	20 57 S	336 38	Do.	17.9	....	22 22 W	3	....	....	....	..	....	....	......	..	C1, D5	....	256	8	MS	bc
175CVI	21 41 S	335 54	Jan 3	5.7	....	22 33 W	3	....	....	....	..	....	....	......	..	C1, D5	....	242	6	S	bc
176CVI	22 24 S	335 09	Do.	....	....	....	..	14.5	....	29 04 S	3	14.6	....	.2277	3	D5	189.1234†	242	5	S	bc
177CVI	22 38 S	334 52	Do.	17.9	....	22 08 W	3	....	....	....	..	....	....	......	..	C1, D5	....	256	5	S	bc
178CVI	23 25 S	334 03	Jan 4	5.6	....	21 42 W	3	....	....	....	..	....	....	......	..	C1, D5	....	242	4	S	bc
179CVI	23 55 S	333 35	Do.	....	....	....	..	14.4	....	29 19 S	3	14.4	....	.2271	3	D5	189.1234†	242	8	S	bc
180CVI	24 02 S	333 31	Do.	17.7	....	21 31 W	3	....	....	....	..	....	....	......	..	C1, D5	....	242	8	S	bc
181CVI	24 32 S	333 06	Jan 5	5.6	....	20 55 W	2	....	....	....	..	....	....	......	..	C1	....	242	6	S	bc
182CVI	24 59 S	332 38	Do.	....	....	....	..	14.4	....	29 50 S	3	14.4	....	.2235	3	D5	189.1234†	259	4	S	bc
183CVI	25 10 S	332 23	Do.	17.7	....	20 47 W	3	....	....	....	..	....	....	......	..	C1, D5	....	250	6	MS	bc
184CVI	26 02 S	331 14	Jan 6	6.2	....	20 01 W	2	....	....	....	..	....	....	......	..	C1	....	253	10	MR	c
185CVI	26 43 S	330 23	Do.	....	....	....	..	14.4	....	30 09 S	1	14.4	....	.2237	2	D5	189.1234	253	10	R	c
186CVI	26 55 S	330 11	Do.	17.2	....	19 22 W	2	....	....	....	..	....	....	......	..	C1	....	236	10	MR	c
187CVI	27 54 S	329 29	Jan 7	7.4	....	19 16 W	2	....	....	....	..	....	....	......	..	C1, D5	....	242	12	MR	c
188CVI	28 07 S	329 12	Do.	....	....	....	..	14.5	....	30 08 S	1	14.5	....	.2210	1	D5	189.1234†	270	13	M	c
189CVI	28 58 S	326 11	Jan 8	....	....	....	..	14.5	....	29 34 S	1	14.5	....	.2230	2	D5	189.1234†	270	18	R	or
190CVI	30 12 S	322 50	Jan 9	....	....	....	..	14.5	....	28 56 S	2	14.5	....	.2243	2	D5	189.1234†	264	16	MR	c
191CVI	30 19 S	322 31	Do.	17.2	....	13 36 W	2	....	....	....	..	....	....	......	..	C1, D5	....	219	24	MR	bc
192CVI	30 22 S	322 25	Do.	18.5	....	14 07 W	3	....	....	....	..	....	....	......	..	C1, D5	....	248	24	MR	bc
193CVI	30 51 S	321 53	Jan 10	5.4	....	13 26 W	3	....	....	....	..	....	....	......	..	C1, D5	....	228	14	MR	bc
194CVI	31 06 S	321 25	Do.	....	....	....	..	14.5	....	28 53 S	3	14.5	....	.2249	3	D5	189.1234†	264	12	M	bc
195CVI	31 16 S	321 06	Do.	17.6	....	12 36 W	3	....	....	....	..	....	....	......	..	C1, D5	....	242	11	ML	bc
196CVI	32 02 S	319 51	Jan 11	5.4	....	11 18 W	3	....	....	....	..	....	....	......	..	C1, D5	....	225	6	MS	bc
197CVI	32 49 S	319 18	Do.	....	....	....	..	14.7	....	29 32 S	3	14.7	....	.2271	3	D5	189.1234†	259–236	6	M	bc
198CVI	33 04 S	319 13	Do.	18.0	....	10 28 W	3	....	....	....	..	....	....	......	..	C1, D5	....	343	13	ML	bc
199CVI	32 58 S	317 58	Jan 12	5.6	....	9 50 W	3	....	....	....	..	....	....	......	..	C1, D5	....	253	11	L	bc

FINAL RESULTS OF OCEAN MAGNETIC OBSERVATIONS ON THE CARNEGIE, 1915–1921—*Continued.*

CRUISE VI, ATLANTIC OCEAN, 1919–1920—*Continued.*

Station	Lat.	Long. East of Gr.	Date	Declination				Inclination				Hor. intensity				Instruments		Remarks			Wea-ther
				L. M. T.		Value	Wt.	L. M. T.		Value	Wt.	L. M. T.		Value	Wt.	Compass	Dip Circle	Course	Roll	Sea	
	° ′	° ′	1920	h	h	° ′		h	h	° ′		h	h	c. g. s.				°	°		
200CVI	33 31 S	316 26	Jan 13	7.5	....	8 19 W	2	....	....	....	..	....	....	......	..	C1	....	242	6	S	o
201CVI	33 57 S	315 59	Do.	....	....	....	..	14.6	....	29 34 S	3	14.6	....	0.2306	3	D5	189.1234†	231–214	5	M	bc
202CVI	34 01 S	315 58	Do.	18.0	....	7 47 W	3	....	....	....	..	....	....	......	..	C1, D5	....	343	4	S	bc
203CVI	33 59 S	315 56	Do.	18.8	....	7 49 W	3	....	....	....	..	....	....	......	..	C1	....	332	4	S	o
204CVI	33 58 S	315 37	Jan 14	5.5	....	7 41 W	3	....	....	....	..	....	....	......	..	C1, D5	....	219	7	S	bc
205CVI	34 00 S	314 45	Do.	....	....	....	..	14.7	....	29 18 S	2	14.7	....	.2310	2	D5	189.1234†	202	7	MR	o
206CVI	33 54 S	314 14	Do.	18.0	....	6 37 W	2	....	....	....	..	....	....	......	..	C1	....	290	13	MR	o
207CVI	33 40 S	312 27	Jan 15	6.8	....	5 05 W	3	....	....	....	..	....	....	......	..	C1, D5	....	281	18	MR	o
208CVI	33 34 S	311 44	Do.	....	....	....	..	14.5	....	27 59 S	3	14.5	....	.2346	3	D5	189.1234†	270	12	ML	bc
209CVI	33 34 S	311 28	Do.	18.6	....	4 24 W	3	....	....	....	..	....	....	......	..	C1, D5	....	315	15	ML	bc
210CVI	33 40 S	310 42	Jan 16	5.6	....	3 23 W	3	....	....	....	..	....	....	......	..	C1, D5	....	250	14	ML	bc
211CVI	34 14 S	309 14	Do.	....	....	....	..	14.7	....	28 15 S	1	14.7	....	.2361	2	D5	189.1234†	270	8	M	o
212CVI	34 20 S	308 36	Do.	17.9	....	1 36 W	2	....	....	....	..	....	....	......	..	C1, D5	....	242	11	MR	bc
213CVI	34 21 S	308 24	Do.	18.8	....	1 19 W	3	....	....	....	..	....	....	......	..	C1, D5	....	276	11	MR	bc
214CVI	34 29 S	306 37	Jan 17	5.6	....	0 07 E	3	....	....	....	..	....	....	......	..	C1, D5	....	248	8	MS	bc
215CVI[1]	35 01 S	304 45	Jan 18	6.0	....	1 59 E	3	....	....	....	..	....	....	......	..	C1	....	259	4	S	bc
216CVI	37 04 S	305 01	Feb 24	6.6	....	2 12 E	3	....	....	....	..	....	....	......	..	C1, D5	....	135	14	MS	bc
217CVI	37 32 S	305 28	Do.	....	....	....	..	15.8	....	31 22 S	2	15.8	....	.2401	2	D5	E17,189.234	135	10	SL	bc
218CVI	37 38 S	305 32	Do.	18.1	....	2 14 E	3	....	....	....	..	....	....	......	..	C1, D5	....	135	11	MS	bc
219CVI	38 58 S	307 04	Feb 25	7.6	....	1 13 E	2	....	....	....	..	....	....	......	..	C1, D5	....	135	14	M	o
220CVI	39 52 S	308 09	Do.	....	....	....	..	15.8	....	33 53 S	3	15.8	....	.2400	3	D5	E17,189.1234†	141	6	M	o
221CVI	40 02 S	308 19	Do.	18.0	....	0 38 E	2	....	....	....	..	....	....	......	..	C1, D5	....	141	10	M	bc
222CVI	40 27 S	309 31	Feb 26	6.6	....	0 08 W	2	....	....	....	..	....	....	......	..	C1, D5	....	11	12	M	bc
223CVI	40 24 S	310 37	Do.	....	....	....	..	15.1	....	34 30 S	2	15.1	....	.2372	2	D5	189.1234†	90	15	MR	bc
224CVI	40 24 S	310 59	Do.	17.7	....	1 03 W	2	....	....	....	..	....	....	......	..	C1, D5	....	107	12	MR	bc
225CVI	40 48 S	311 50	Feb 27	6.5	....	1 50 W	2	....	....	....	..	....	....	......	..	C1, D5	....	214	10	MR	bc
226CVI	41 54 S	312 05	Do.	....	....	....	..	14.8	....	36 10 S	1	14.8	....	.2380	1	D5	189.1234†	158	13	MR	bc
227CVI	42 16 S	312 22	Do.	18.0	....	1 41 W	2	....	....	....	..	....	....	......	..	C1, D5	....	158	16	MR	bc
228CVI	43 28 S	313 18	Feb 28	6.4	....	2 01 W	3	....	....	....	..	....	....	......	..	C1, D5	....	186	10	M	bc
229CVI	44 17 S	313 51	Do.	....	....	....	..	14.7	....	38 42 S	2	14.7	....	.2391	2	D5	189.1234†	140	11	M	o
230CVI	44 56 S	314 34	Do.	20.3	....	2 16 W	2	....	....	....	..	....	....	......	..	C1	....	135	13	M	bc
231CVI	45 54 S	316 56	Feb 29	8.3	....	4 23 W	2	....	....	....	..	....	....	......	..	C1, D5	....	101	14	RH	cu
232CVI	46 07 S	318 19	Do.	....	....	....	..	14.3	....	41 26 S	1	14.3	....	.2345	1	D5	189.234	101	24	RH	o
233CVI	45 47 S	323 30	Mar 1	....	....	....	..	14.7	....	42 16 S	2	14.7	....	.2306	2	D5	189.1234†	79	12	RH	o
234CVI	45 41 S	323 54	Do.	16.7	....	9 10 W	2	....	....	....	..	....	....	......	..	C1, D5	....	84	12	RH	o
235CVI	45 11 S	326 27	Mar 2	7.7	....	11 17 W	2	....	....	....	..	....	....	......	..	C1, D5	....	45	14	H	o
236CVI	45 06 S	327 49	Do.	....	....	....	..	15.0	....	43 23 S	2	14.9	....	.2242	2	D5	189.1234†	118	24	ML	bc
237CVI	45 10 S	328 06	Do.	16.8	....	12 37 W	2	....	....	....	..	....	....	......	..	C1, D5	....	129	16	ML	bc
238CVI	45 22 S	329 35	Mar 3	6.5	....	13 36 W	3	....	....	....	..	....	....	......	..	C1, D5	....	118	12	ML	bc
239CVI	45 34 S	330 43	Do.	....	....	....	..	14.7	....	44 46 S	2	14.7	....	.2218	2	D5	189.1234†	124,135	20	M	o
240CVI	45 42 S	331 19	Do.	17.7	....	14 25 W	1	....	....	....	..	....	....	......	..	C1	....	115	12	M	o
241CVI	45 45 S	331 48	Do.	20.1	....	14 55 W	2	....	....	....	..	....	....	......	..	C1	....	135	12	M	bc
242CVI	45 59 S	333 35	Mar 4	6.3	....	15 34 W	2	....	....	....	..	....	....	......	..	C1, D5	....	158	15	M	bc
243CVI	45 35 S	335 37	Do.	....	....	....	..	14.9	....	47 05 S	3	14.9	....	.2138	3	D5	189.1234†	84	11	M	bc
244CVI	45 25 S	336 15	Do.	17.5	....	17 03 W	2	....	....	....	..	....	....	......	..	C1, D5	....	84	14	ML	bc
245CVI	44 36 S	338 47	Mar 5	6.3	....	18 55 W	3	....	....	....	..	....	....	......	..	C1, D5	....	79	8	MS	b
246CVI	43 59 S	340 27	Do.	....	....	....	..	14.6	....	48 11 S	3	14.7	....	.2064	3	D5	189.1234†	79	10	MS	b
247CVI	43 44 S	341 04	Do.	17.9	....	21 37 W	3	....	....	....	..	....	....	......	..	C1, D5	....	62	9	MS	bc

[1] From January 19 to February 21 the *Carnegie* was at Buenos Aires.

CRUISE VI, ATLANTIC OCEAN, 1919–1920—*Continued.*

	° ′	° ′	*1920*	h	h	° ′		h	h	° ′		h	h	c.g.s.				°	°		
248CVI	42 46 S	343 25	Mar 6	6.2		22 09 W	3									C1, D5		79	6	S	b
249CVI	42 08 S	345 00	Do.					14.8		49 23 S	3	14.8		0.2012	3	D5	189.1234†	84	11	MS	o
250CVI	40 52 S	348 08	Mar 7	10.4		25 35 W	1									C1		124	9	S	o
251CVI	40 42 S	348 33	Do.					14.6		50 23 S	3	14.6		.1963	3	D5	189.1234†	84	10	MS	o
252CVI	40 12 S	349 48	Mar 8	8.4		26 20 W	2									C1		56	7	S	o
253CVI	40 02 S	350 16	Do.					14.9		51 03 S	3	14.9		.1946	3	D5	189.1234†	65	8	S	bo
254CVI	39 59 S	350 20	Do.	16.2		26 29 W	2									C1, D5		84	11	S	bo
255CVI	38 59 S	351 42	Mar 9	9.7		26 32 W	2									C1		45	5	L	o
256CVI	38 31 S	351 59	Do.					14.5		51 07 S	3	14.5		.1937	3	D5	189.1234†	59	8	SL	bo
257CVI	38 21 S	352 06	Do.	16.1		27 19 W	2									C1, D5		51	8	ML	bo
258CVI	37 03 S	352 58	Mar 10	9.8		27 25 W	1									C1		39	10	SL	o
259CVI	36 44 S	353 14	Do.					14.7		51 11 S	3	14.7		.1938	3	D5	189.1234†	68	8	ML	o
260CVI	36 34 S	353 23	Do.	16.8		27 33 W	1									C1		62	10	L	o
261CVI	36 14 S	353 50	Mar 11	6.9		27 23 W	2									C1		90	8	S	of
262CVI	36 09 S	354 10	Do.					14.6		51 17 S	3	14.6		.1917	3	D5	189.1234†	96	12	SL	s
263CVI	36 08 S	354 18	Do.	16.7		28 00 W	3									C1, D5		96	8	SL	bos
264CVI	35 51 S	355 28	Mar 12	6.0		27 16 W	1									C1		112	6	S	o
265CVI	35 48 S	356 49	Do.					14.8		52 36 S	3	14.8		.1893	3	D5	189.1234†	118	6	S	bo
266CVI	35 52 S	357 10	Do.	17.0		27 49 W	3									C1, D5		112	6	MS	bo
267CVI	35 27 S	359 36	Mar 13	6.8		28 44 W	3									C1, D5		90	7	C	bo
268CVI	34 48 S	0 26	Do.					14.7		54 20 S	2	14.7		.1854	2	D5	189.1234†	68	20	C	bo
269CVI	34 34 S	0 42	Do.	17.2		28 24 W	2									C1, D5		68	18	C	bo
270CVI	33 20 S	1 45	Mar 14	6.4		28 38 W	3									C1, D5		62	20	MLC	bo
271CVI	32 46 S	2 13	Do.					14.9		54 31 S	2	14.9		.1814	2	D5	189.1234†	62	20	ML	bo
272CVI	32 38 S	2 19	Do.	17.5		29 07 W	3									C1, D5		62	11	ML	bo
273CVI	32 22 S	2 27	Mar 15	6.5		28 34 W	2									C1, D5		62	13	L	bo
274CVI	31 50 S	2 52	Do.	17.6		28 34 W	3									C1, D5		62	9	L	bo
275CVI	31 15 S	3 16	Mar 16	7.7		28 19 W	2									C1		62	6	S	o
276CVI	30 47 S	3 36	Do.					14.5		54 02 S	3	14.5		.1882	3	D5	189.1234†	68	5	SL	bo
277CVI	30 29 S	3 52	Do.	17.3		28 14 W	3									C1, D5		68	5	ML	bo
278CVI	28 52 S	4 45	Mar 17	6.4		27 31 W	3									C1, D5		51	6	MC	bo
279CVI	27 50 S	5 24	Do.					14.6		53 35 S	2	14.6		.1899	2	D5	189.1234†	65	12	MR	bo
280CVI	27 32 S	5 37	Do.	17.2		26 59 W	2									C1, D5		51	11	C	bo
281CVI	25 41 S	7 04	Mar 18	8.6		26 37 W	1									C1		68	10	C	o
282CVI	24 52 S	7 19	Do.					14.5		52 39 S	2	14.5		.1944	2	D5	189.1234†	34	13	R	bo
283CVI	24 30 S	7 21	Do.	17.2		24 53 W	3									C1, D5		34	20	MR	bo
284CVI	22 37 S	7 32	Mar 19	8.2		24 08 W	2									C1		34	10	M	o
285CVI	21 59 S	7 38	Do.					14.6		50 17 S	3	14.6		.2018	3	D5	189.1234†	34	12	MS	o
286CVI	21 47 S	7 40	Do.	16.6		24 26 W	3									C1, D5		45	18	MS	bo
287CVI	20 00 S	7 49	Mar 20	9.0		23 13 W	1									C1		34	6	S	o
288CVI	19 53 S	7 50	Do.	10.1		23 15 W	1									C1		34	6	S	o
289CVI	19 24 S	7 53	Do.					14.4		48 39 S	3	14.4		.2100	3	D5	189.1234†	28	11	MS	bo
290CVI	19 05 S	7 54	Do.	17.1		22 41 W	3									C1, D5		37	5	MS	bo
291CVI	17 08 S	8 02	Mar 21	8.7		21 19 W	2									C1		28	9	S	o
292CVI	16 23 S	8 04	Do.					14.8		46 07 S	3	14.8		.2206	3	D5	189.1234†	28	8	S	o
293CVI	16 08 S	8 06	Do.	16.7		20 50 W	3									C1, D5		31	15	MS	bo
294CVI	14 17 S	7 32	Mar 22	9.0		20 12 W	1									C1		45	13	L	o
295CVI	13 45 S	7 26	Do.					14.5		42 43 S	3	14.5		.2295	3	D5	189.1234†	6	14	MS	o
296CVI	13 39 S	7 24	Do.	15.4		19 59 W	1									C1		62	14	L	o
297CVI	13 33 S	7 14	Do.	17.4		20 04 W	3									C1, D5		332	10	ML	bo
298CVI	13 33 S	5 29	Mar 23	6.5		20 05 W	3									C1, D5		281	10	MS	bo
299CVI	13 37 S	4 28	Do.					14.6		41 39 S	3	14.6		.2292	3	D5	189.1234†	276	8	S	bo
300CVI	13 39 S	4 05	Do.	18.0		20 50 W	2									C1		276	10	S	o
301CVI	13 56 S	2 27	Mar 24	8.5		21 40 W	1									C1		273	9	L	o
302CVI	14 01 S	1 53	Do.					14.2		40 20 S	2	14.2		.2308	2	D5	189.234	315–270	12	ML	o
303CVI	14 01 S	1 40	Do.	18.1		22 02 W	2									C1		276	11	L	o
304CVI	14 33 S	359 53	Mar 25	8.3		23 01 W	2									C1		270	11	L	o
305CVI	14 47 S	359 09	Do.					14.6		39 29 S	2	14.6		.2286	2	D5	189.1234†	270	9	SL	bo
306CVI	14 54 S	358 49	Do.	16.8		23 20 W	2									C1, D5		267	7	ML	bo

FINAL RESULTS OF OCEAN MAGNETIC OBSERVATIONS ON THE CARNEGIE, 1915–1921—*Continued.*

CRUISE VI, ATLANTIC OCEAN, 1919–1920—*Continued.*

Station	Lat.	Long. East of Gr.	Date	Declination L. M. T.		Declination Value	Declination Wt.	Inclination L. M. T.		Inclination Value	Inclination Wt.	Hor. intensity L. M. T.		Hor. intensity Value	Hor. intensity Wt.	Instruments Compass	Instruments Dip Circle	Remarks Course	Remarks Roll	Remarks Sea	Weather
	° ′	° ′	1920	h	h	° ′		h	h	° ′		h	h	c. g. s.				°	°		
307CVI	15 42 S	356 52	Mar 26	7.1	....	24 13 W	2	....	....	....	..	....	....	......	..	C1	....	264	9	L	o
308CVI	15 47 S	356 01	Do.	....	....	....	..	14.2	....	38 45 S	2	14.2	....	0.2258	2	D5	189.1234†	287	18	ML	bc
309CVI[1]	15 48 S	355 42	Do.	16.8	....	24 17 W	2	....	....	....	..	....	....	......	..	C1	....	287	12	L	bc
310CVI	17 06 S	352 18	Apr 4	7.8	....	25 01 W	2	....	....	....	..	....	....	......	..	C1, D5	....	259	15	M	bc
311CVI	17 37 S	351 33	Do.	....	....	....	..	14.5	....	37 15 S	2	14.4	....	.2259	2	D5	189.1234†	248	10	M	bc
312CVI	17 48 S	351 22	Do.	16.5	....	25 18 W	2	....	....	....	..	....	....	......	..	C1	....	248	16	M	c
313CVI	17 56 S	351 14	Do.	17.9	....	25 09 W	2	....	....	....	..	....	....	......	..	C1	....	248	12	M	c
314CVI	19 15 S	349 45	Apr 5	8.1	....	25 39 W	1	....	....	....	..	....	....	......	..	C1	....	248	9	M	c
315CVI	19 46 S	349 14	Do.	....	....	....	..	14.3	....	37 11 S	3	14.3	....	.2219	3	D5	189.1234†	242	18	M	bc
316CVI	20 04 S	348 58	Do.	17.3	....	25 54 W	3	....	....	....	..	....	....	......	..	C1, D5	....	242	10	M	bc
317CVI	21 24 S	347 46	Apr 6	7.5	....	25 52 W	2	....	....	....	..	....	....	......	..	C1	....	242	9	M	c
318CVI	21 29 S	347 40	Do.	8.5	....	26 26 W	2	....	....	....	..	....	....	......	..	C1	....	242	9	M	c
319CVI	21 44 S	347 28	Do.	....	....	....	..	14.4	....	37 52 S	3	14.4	....	.2188	3	D5	189.1234†	242	9	MS	bc
320CVI	21 53 S	347 20	Do.	17.0	....	25 40 W	3	....	....	....	..	....	....	......	..	C1, D5	....	242	17	M	bc
321CVI	22 34 S	346 44	Apr 7	6.5	....	25 45 W	3	....	....	....	..	....	....	......	..	C1, D5	....	242	15	SL	bc
322CVI	22 48 S	346 35	Do.	....	....	....	..	14.4	....	38 21 S	3	14.4	....	.2165	3	D5	189.1234†	242	20	SL	bc
323CVI	22 49 S	346 34	Do.	17.2	....	25 18 W	3	....	....	....	..	....	....	......	..	C1, D5	....	242	16	MS	bc
324CVI	23 43 S	346 01	Apr 8	6.5	....	26 17 W	3	....	....	....	..	....	....	......	..	C1, D5	....	231	8	MS	bc
325CVI	24 33 S	345 40	Do.	....	....	....	..	14.5	....	38 59 S	3	14.5	....	.2142	3	D5	189.1234†	219	5	S	bc
326CVI	24 49 S	345 40	Apr 9	7.5	....	25 34 W	3	....	....	....	..	....	....	......	..	C1, D5	....	180,225	11	ML	cq
327CVI	25 41 S	345 24	Do.	16.4	....	25 42 W	1	....	....	....	..	....	....	......	..	C1	....	231	17	C	c
328CVI	26 30 S	344 42	Apr 10	8.1	....	25 53 W	1	....	....	....	..	....	....	......	..	C1	....	248	35	MR	c
329CVI	26 55 S	344 11	Do.	....	....	....	..	14.4	....	39 37 S	1	14.3	....	.2127	1	D5	189.1234†	248	27	RC	cq
330CVI	27 02 S	344 04	Do.	15.9	....	25 26 W	2	....	....	....	..	....	....	......	..	C1, D5	....	214	25	RC	bc
331CVI	29 30 S	342 38	Apr 11	....	....	....	..	14.5	....	40 40 S	2	14.5	....	.2100	2	D5	189.1234†	242	13	MR	o
332CVI	29 38 S	342 38	Do.	15.6	....	25 11 W	2	....	....	....	..	....	....	......	..	C1	....	242	13	MR	c
333CVI	29 51 S	342 38	Do.	17.4	....	25 06 W	2	....	....	....	..	....	....	......	..	C1	....	242	13	MR	bc
334CVI	30 40 S	342 37	Apr 12	7.1	....	24 47 W	3	....	....	....	..	....	....	......	..	C1, D5	....	242	20	ML	bc
335CVI	31 16 S	342 42	Do.	....	....	....	..	14.3	....	41 46 S	3	14.3	....	.2072	3	D5	189.1234†	180	17	M	bct
336CVI	31 24 S	342 46	Do.	15.5	....	25 00 W	2	....	....	....	..	....	....	......	..	C1	....	180	19	SL	c
337CVI	31 33 S	342 52	Do.	17.1	....	25 07 W	3	....	....	....	..	....	....	......	..	C1, D5	....	180	20	ML	cr
338CVI	33 02 S	343 49	Apr 13	6.8	....	24 51 W	3	....	....	....	..	....	....	......	..	C1, D5	....	191	25	MR	bc
339CVI	33 50 S	344 22	Do.	....	....	....	..	14.6	....	44 43 S	2	14.6	....	.2034	2	D5	189.1234†	180	21	MR	bc
340CVI	33 56 S	344 26	Do.	15.5	....	25 01 W	1	....	....	....	..	....	....	......	..	C1	....	180	21	MR	o
341CVI	34 04 S	344 32	Do.	16.5	....	24 57 W	2	....	....	....	..	....	....	......	..	C1, D5	....	180	18	MR	cr
342CVI	35 51 S	345 59	Apr 14	7.1	....	25 07 W	2	....	....	....	..	....	....	......	..	C1, D5	....	146	25	MR	bc
343CVI	36 06 S	346 44	Do.	....	....	....	..	14.3	....	47 14 S	1	14.3	....	.2008	1	D5	189.1234†	158	17	RC	bcq
344CVI	36 12 S	346 55	Do.	16.3	....	25 28 W	2	....	....	....	..	....	....	......	..	C1, D5	....	158	14	MR	bc
345CVI	36 23 S	348 44	Apr 15	7.0	....	26 19 W	3	....	....	....	..	....	....	......	..	C1, D5	....	141	21	MRL	bc
346CVI	36 25 S	349 19	Do.	....	....	....	..	14.4	....	49 14 S	3	14.4	....	.1954	3	D5	189.1234†	124	10	ML	bc
347CVI	36 28 S	349 37	Do.	16.4	....	26 32 W	3	....	....	....	..	....	....	......	..	C1, D5	....	124	12	ML	bc
348CVI	36 55 S	352 13	Apr 16	6.9	....	27 10 W	3	....	....	....	..	....	....	......	..	C1, D5	....	124	9	ML	bc
349CVI	37 09 S	353 41	Do.	....	....	....	..	14.4	....	51 38 S	2	14.4	....	.1919	2	D5	189.1234†	124	9	MR	o
350CVI	37 12 S	354 00	Do.	16.0	....	27 52 W	2	....	....	....	..	....	....	......	..	C1	....	124	9	C	os
351CVI	37 26 S	357 24	Apr 17	9.3	....	28 28 W	2	....	....	....	..	....	....	......	..	C1	....	112	14	MR	o
352CVI	37 26 S	358 26	Do.	....	....	....	..	14.6	....	54 38 S	2	14.6	....	.1848	2	D5	189.1234†	112	9	M	o
353CVI	37 26 S	358 41	Do.	15.9	....	28 32 W	2	....	....	....	..	....	....	......	..	C1	....	112	9	MR	o
354CVI	37 01 S	3 02	Apr 18	....	....	....	..	14.6	....	55 49 S	1	14.6	....	.1805	1	D5	189.1234	107	26	RC	o

[1] From March 27 to April 3, the *Carnegie* was at St. Helena.

CRUISE VI, ATLANTIC OCEAN, 1919–1920—*Concluded.*

	° ′	° ′	*1920*	*h*	*h*	° ′		*h*	*h*	° ′		*h*	*h*	*c. g. s.*				°	°		
355CVI	36 57 S	3 24	Apr 18	16.2	....	29 16 W	2	....	....	....	..	....	....	......	..	C1, D5	....	107	20	RC	c
356CVI	36 26 S	5 48	Apr 19	7.2	....	28 41 W	2	....	....	....	..	....	....	......	..	C1, D5	....	79	20	MRC	bc
357CVI	35 58 S	6 11	Do.	....	....	....	..	14.5	....	57 46 S	2	14.5	....	0.1762	2	D5	189.1234†	219	9	M	bc
358CVI	37 21 S	7 16	Apr 20	8.1	....	29 22 W	2	....	....	....	..	....	....	......	..	C1, D5	....	141	15	MC	c
359CVI	37 36 S	7 59	Do.	....	....	....	..	14.4	....	59 07 S	1	14.4	....	.1733	1	D5	189.1234†	135	20	MRC	c
360CVI	37 38 S	8 07	Do.	15.3	....	29 02 W	2	....	....	....	..	....	....	......	..	C1	....	141	20	C	c
361CVI	37 34 S	10 01	Apr 21	7.3	....	28 41 W	3	....	....	....	..	....	....	......	..	C1, D5	....	112	5	M	bc
362CVI	37 29 S	10 59	Do.	....	....	....	..	14.4	....	60 27 S	3	14.4	....	.1692	3	D5	189.1234†	112	9	M	bc
363CVI	37 29 S	11 10	Do.	15.7	....	29 01 W	2	....	....	....	..	....	....	......	..	C1	....	112	9	M	c
364CVI	36 56 S	12 34	Apr 22	6.9	....	28 16 W	3	....	....	....	..	....	....	......	..	C1, D5	....	79	8	S	bc
365CVI	36 35 S	13 11	Do.	....	....	....	..	14.2	....	60 33 S	3	14.2	....	.1680	3	D5	189.1234†	79	8	S	bc
366CVI	36 30 S	13 19	Do.	15.7	....	27 47 W	2	....	....	....	..	....	....	......	..	C1	....	79	9	S	c
367CVI	35 37 S	15 14	Apr 23	8.6	....	25 58 W	3	....	....	....	..	....	....	......	..	C1, D5	....	79	8	S	c
368CVI	35 15 S	16 14	Do.	....	....	....	..	14.4	....	61 16 S	3	14.4	....	.1660	3	D5	189.1234†	90	4	S	c
369CVI[1]	35 10 S	16 26	Do.	15.6	....	26 52 W	3	....	....	....	..	....	....	......	..	C1, D5	....	90	9	S	c
370CVI	35 18 S	17 53	May 21	7.9	....	26 13 W	2	....	....	....	..	....	....	......	..	C1	....	208	8	S	c
371CVI	35 25 S	17 53	Do.	9.0	....	26 26 W	2	....	....	....	..	....	....	......	..	D5	....	208	10	M	bc
372CVI	36 15 S	17 50	Do.	....	....	....	..	15.4	....	62 05 S	3	15.4	....	.1634	3	D5	EI7,189.1234†	202	9	S	c
373CVI	36 23 S	17 50	Do.	16.6	....	26 37 W	2	....	....	....	..	....	....	......	..	C1	....	202	9	S	bc
374CVI	37 48 S	18 40	May 22	7.5	....	26 43 W	3	....	....	....	..	....	....	......	..	C1, D5	....	191	8	M	c
375CVI	38 44 S	18 54	Do.	....	....	....	..	14.3	....	63 13 S	2	14.4	....	.1578	2	D5	189.1234†	202	10	MR	c

CRUISE VI, INDIAN OCEAN, 1920.

	° ′	° ′	*1920*	*h*	*h*	° ′		*h*	*h*	° ′		*h*	*h*	*c. g. s.*				°	°		
376CVI	39 40 S	21 29	May 23	8.6	....	26 51 W	1	....	....	....	..	....	....	......	..	C1, D5	....	124	45	RB	cqu
377CVI	39 39 S	22 34	Do.	....	....	....	..	14.5	....	64 19 S	2	14.5	....	0.1567	2	D5	189.1234†	124	10	R	crq
378CVI	39 39 S	24 47	May 24	7.8	....	25 08 W	2	....	....	....	..	....	....	......	..	C1, D5	....	135	15	ML	bc
379CVI	39 42 S	25 34	Do.	....	....	....	..	14.6	....	64 38 S	2	14.6	....	.1555	2	D5	189.1234†	101	12	M	bc
380CVI	39 41 S	25 42	Do.	15.8	....	25 53 W	2	....	....	....	..	....	....	......	..	C1, D5	....	101	18	ML	bc
381CVI	39 23 S	28 22	May 25	7.7	....	25 02 W	2	....	....	....	..	....	....	......	..	C1, D5	....	101	27	R	bc
382CVI	39 19 S	29 24	Do.	....	....	....	..	14.4	....	66 25 S	2	14.4	....	.1472	2	D5	189.1234†	90	15	R	bc
383CVI	39 18 S	29 34	Do.	15.6	....	25 41 W	2	....	....	....	..	....	....	......	..	C1, D5	....	90	25	RH	bc
384CVI	38 42 S	31 49	May 26	9.1	....	22 45 W	1	....	....	....	..	....	....	......	..	C1, D5	....	101	20	RC	c
385CVI	38 18 S	32 29	Do.	....	....	....	..	14.4	....	65 19 S	1	14.4	....	.1518	1	D5	189.1234	73	18	RB	cqr
386CVI	36 42 S	34 33	May 27	8.4	....	22 14 W	2	....	....	....	..	....	....	......	..	C1, D5	....	39	25	RLH	bc
387CVI	36 14 S	35 09	Do.	....	....	....	..	14.4	....	65 33 S	2	14.4	....	.1520	2	D5	189.1234†	79	11	RL	bc
388CVI	36 07 S	35 18	Do.	15.8	....	20 34 W	2	....	....	....	..	....	....	......	..	C1, D5	....	79	32	LH	bc
389CVI	35 00 S	37 14	May 28	8.2	....	20 04 W	2	....	....	....	..	....	....	......	..	C1, D5	....	135	33	LH	bc
390CVI	34 37 S	38 04	Do.	....	....	....	..	14.2	....	64 59 S	2	14.2	....	.1543	2	D5	189.1234†	90	24	MH	bc
391CVI	34 32 S	38 20	Do.	15.9	....	19 45 W	2	....	....	....	..	....	....	......	..	C1, D5	....	90	15	LH	bc
392CVI	33 50 S	40 32	May 29	10.8	....	19 06 W	2	....	....	....	..	....	....	......	..	C1, D5	....	90	14	ML	bc
393CVI	33 42 S	41 03	Do.	....	....	....	..	14.4	....	64 32 S	3	14.4	....	.1568	3	D5	189.1234†	90	12	ML	bc
394CVI	33 39 S	41 15	Do.	15.7	....	18 47 W	3	....	....	....	..	....	....	......	..	C1, D5	....	90	16	ML	bc
395CVI	33 08 S	43 28	May 30	7.3	....	18 58 W	3	....	....	....	..	....	....	......	..	C1, D5	....	93	8	MS	bc
396CVI	33 14 S	44 28	Do.	....	....	....	..	13.8	....	64 02 S	2	13.8	....	.1611	2	D5	189.134	112	11	M	c
397CVI	33 16 S	44 44	Do.	15.5	....	18 01 W	2	....	....	....	..	....	....	......	..	C1	....	112	10	M	c
398CVI	34 46 S	47 04	May 31	9.6	....	19 43 W	2	....	....	....	..	....	....	......	..	C1	....	146	20	RC	c
399CVI	34 55 S	47 18	Do.	....	....	....	..	14.1	....	64 35 S	2	14.1	....	.1602	2	D5	189.1234†	22	15	R	cqr
400CVI	34 50 S	47 17	Do.	15.8	....	19 32 W	2	....	....	....	..	....	....	......	..	C1	....	22	25	R	c
401CVI	34 30 S	47 23	Jun 1	7.4	....	19 17 W	2	....	....	....	..	....	....	......	..	C1, D5	....	0, Var.	27	L	bc
402CVI	32 59 S	48 13	Jun 2	8.1	....	17 54 W	2	....	....	....	..	....	....	......	..	C1, D5	....	22	26	R	bc
403CVI	32 20 S	48 51	Do.	....	....	....	..	14.3	....	63 34 S	1	14.3	....	.1662	1	D5	189.1234†	79	20	RH	bc
404CVI	32 10 S	49 06	Do.	16.1	....	17 34 W	2	....	....	....	..	....	....	......	..	C1	....	79	20	R	c
405CVI	31 29 S	51 29	Jun 3	7.6	....	17 22 W	2	....	....	....	..	....	....	......	..	C1, D5	....	96	15	R	cr
406CVI	31 18 S	52 37	Do.	....	....	....	..	14.4	....	62 35 S	1	14.4	....	.1747	1	D5	189.1234†	101	17	R	bcq
407CVI	31 16 S	52 52	Do.	15.8	....	17 20 W	2	....	....	....	..	....	....	......	..	C1, D5	....	101	15	RH	bcq

[1] From April 24 to May 20 the *Carnegie* was at Cape Town.

FINAL RESULTS OF OCEAN MAGNETIC OBSERVATIONS ON THE CARNEGIE, 1915–1921—*Continued.*

CRUISE VI, INDIAN OCEAN, 1920—*Continued.*

Station	Lat.	Long. East of Gr.	Date	Declination L. M. T.		Declination Value	Wt.	Inclination L. M. T.		Inclination Value	Wt.	Hor. intensity L. M. T.		Hor. intensity Value	Wt.	Instruments Compass	Instruments Dip Circle	Remarks Course	Roll	Sea	Weather
	° ′	° ′	1920	h	h	° ′		h	h	° ′		h	h	c. g. s.				°	°		
408CVI	30 46 S	55 34	Jun 4	7.7	....	17 31 W	2	....	....	....	..	....	....	......	..	C1, D5	....	101	19	RH	bc
409CVI	30 33 S	56 49	Do.	....	....	....	..	14.4	....	60 55 S	2	14.4	....	0.1842	2	D5	189.1234†	107	30	RH	bc
410CVI	30 31 S	57 08	Do.	16.0	....	18 25 W	1	....	....	....	..	....	....	......	..	C1, D5	....	107	22	RH	bcq
411CVI	30 27 S	57 17	Do.	16.8	....	18 04 W	2	....	....	....	..	....	....	......	..	C1, D5	....	79	22	RH	bcq
412CVI	30 11 S	60 08	Jun 5	8.1	....	18 41 W	2	....	....	....	..	....	....	......	..	C1, D5	....	107	15	R	bc
413CVI	29 52 S	61 10	Do.	....	....	....	..	14.3	....	60 58 S	2	14.3	....	.1000	2	D5	189.1234†	68	14	R	bcqr
414CVI	29 43 S	61 20	Do.	15.6	....	19 01 W	1	....	....	....	..	....	....	......	..	C1, D5	....	68	20	R	bcqr
415CVI	28 23 S	63 00	Jun 6	7.4	....	18 03 W	2	....	....	....	..	....	....	......	..	C1, D5	....	65	17	MH	bc
416CVI	27 48 S	63 47	Do.	....	....	....	..	14.3	....	59 29 S	2	14.3	....	.2014	2	D5	189.1234†	56	24	MLH	bc
417CVI	27 37 S	63 57	Do.	16.0	....	18 00 W	3	....	....	....	..	....	....	......	..	C1, D5	....	56	15	MH	bc
418CVI	26 22 S	65 09	Jun 7	8.3	....	17 05 W	3	....	....	....	..	....	....	......	..	C1, D5	....	53	6	SL	bc
419CVI	25 51 S	65 32	Do.	....	....	....	..	14.2	....	58 05 S	3	14.2	....	.2114	3	D5	189.1234†	22	8	SL	bc
420CVI	25 37 S	65 36	Do.	16.3	....	16 43 W	3	....	....	....	..	....	....	......	..	C1, D5	....	22	7	SL	bc
421CVI	24 28 S	65 55	Jun 8	7.1	....	15 35 W	3	....	....	....	..	....	....	......	..	C1, D5	....	22	6	S	bc
422CVI	23 34 S	66 06	Do.	....	....	....	..	14.2	....	55 50 S	3	14.2	....	.2229	3	D5	189.1234†	11	10	S	bc
423CVI	23 16 S	66 07	Do.	16.4	....	15 03 W	3	....	....	....	..	....	....	......	..	C1, D5	....	11	12	MS	bc
424CVI	21 30 S	65 59	Jun 9	7.2	....	13 27 W	3	....	....	....	..	....	....	......	..	C1, D5	....	6	14	MS	bc
425CVI	20 28 S	65 52	Do.	....	....	....	..	15.0	....	53 22 S	3	15.0	....	.2353	3	D5	189.1234†	6	10	S	bc
426CVI	20 19 S	65 50	Do.	16.8	....	12 34 W	3	....	....	....	..	....	....	......	..	C1, D5	....	6	12	MS	bc
427CVI	18 24 S	65 36	Jun 10	8.1	....	10 29 W	2	....	....	....	..	....	....	......	..	C1	....	6	11	S	c
428CVI	17 24 S	65 24	Do.	....	....	....	..	14.6	....	49 13 S	3	14.6	....	.2517	3	D5	189.1234	6	15	M	bc
429CVI	17 07 S	65 22	Do.	16.8	....	10 17 W	2	....	....	....	..	....	....	......	..	C1, D5	....	6	16	MLC	bc
430CVI	15 10 S	65 08	Jun 11	6.7	....	8 50 W	2	....	....	....	..	....	....	......	..	C1, D5	....	6	14	MLC	bc
431CVI	14 03 S	65 01	Do.	....	....	....	..	14.4	....	44 37 S	2	14.4	....	.2708	2	D5	189.1234†	6	14	RLC	bc
432CVI	13 39 S	64 58	Do.	16.8	....	8 10 W	2	....	....	....	..	....	....	......	..	C1, D5	....	28	16	MLC	bc
433CVI	11 25 S	64 39	Jun 12	7.2	....	6 55 W	3	....	....	....	..	....	....	......	..	C1, D5	....	6	14	ML	bc
434CVI	10 20 S	64 29	Do.	....	....	....	..	14.3	....	38 53 S	3	14.3	....	.2928	3	D5	189.1234†	6	21	M	bc
435CVI	9 59 S	64 26	Do.	16.7	....	6 14 W	3	....	....	....	..	....	....	......	..	C1, D5	....	45	15	ML	bc
436CVI	7 57 S	64 12	Jun 13	7.2	....	5 18 W	2	....	....	....	..	....	....	......	..	C1	....	6	23	M	bcs
437CVI	7 49 S	64 11	Do.	8.2	....	5 18 W	2	....	....	....	..	....	....	......	..	D5	....	6	10	M	c
438CVI	7 06 S	64 02	Do.	....	....	....	..	14.3	....	33 13 S	3	14.3	....	.3089	3	D5	189.1234†	0	15	M	bc
439CVI	6 50 S	63 56	Do.	17.1	....	5 01 W	3	....	....	....	..	....	....	......	..	C1, D5	....	34	12	M	bcq
440CVI	5 34 S	63 34	Jun 14	6.8	....	4 14 W	3	....	....	....	..	....	....	......	..	C1, D5	....	0	17	M	bc
441CVI	4 54 S	63 29	Do.	....	....	....	..	14.2	....	28 22 S	3	14.2	....	.3215	3	D5	189.1234†	6	12	ML	bc
442CVI	4 42 S	63 30	Do.	16.6	....	4 12 W	3	....	....	....	..	....	....	......	..	C1, D5	....	34	8	MS	bc
443CVI	3 35 S	63 33	Jun 15	6.6	....	3 45 W	3	....	....	....	..	....	....	......	..	C1, D5	....	6	6	S	bc
444CVI	3 04 S	63 32	Do.	....	....	....	..	14.2	....	24 53 S	3	14.2	....	.3291	3	D5	189.1234†	349	10	S	bc
445CVI	2 58 S	63 29	Do.	16.6	....	3 35 W	2	....	....	....	..	....	....	......	..	C1, D5	....	17	7	S	bcs
446CVI	2 30 S	63 19	Jun 16	6.5	....	3 32 W	2	....	....	....	..	....	....	......	..	C1	....	349	8	S	c
447CVI	1 50 S	63 09	Do.	....	....	....	..	14.1	....	22 02 S	3	14.1	....	.3352	3	D5	189.1234†	349	11	SL	c
448CVI	1 36 S	63 06	Do.	17.2	....	3 01 W	3	....	....	....	..	....	....	......	..	C1, D5	....	349	12	S	bcq
449CVI	0 32 S	62 57	Jun 17	6.4	....	2 49 W	3	....	....	....	..	....	....	......	..	C1, D5	....	349	9	S	bc
450CVI	0 08 N	62 55	Do.	....	....	....	..	14.0	....	17 45 S	3	14.0	....	.3426	3	D5	189.1234†	349	10	S	bc
451CVI	0 23 N	62 54	Do.	16.8	....	2 37 W	3	....	....	....	..	....	....	......	..	C1, D5	....	6	8	S	bc
452CVI	1 30 N	62 43	Jun 18	6.3	....	2 23 W	3	....	....	....	..	....	....	......	..	C1, D5	....	343	11	S	bc
453CVI	2 07 N	62 31	Do.	....	....	....	..	14.2	....	13 30 S	3	14.2	....	.3504	3	D5	189.1234†	332	12	S	bc
454CVI	2 23 N	62 25	Do.	17.4	....	2 10 W	3	....	....	....	..	....	....	......	..	C1, D5	....	332	8	S	bc
455CVI	3 28 N	61 55	Jun 19	7.1	....	1 53 W	3	....	....	....	..	....	....	......	..	C1, D5	....	332	7	S	bc
456CVI	4 06 N	61 37	Do.	....	....	....	..	14.4	....	9 11 S	3	14.4	....	.3546	3	D5	189.1234†	338	5	S	bc

CRUISE VI, INDIAN OCEAN, 1920—*Continued.*

	° '	° '	1920	h	h	° '		h	h	° '		h	h	c.g.s.				°	°		
457CVI	4 22 N	61 29	Jun 19	16.5	....	1 38 W	2	....	....	....	..	....	....	......	..	C1	....	332	8	S	o
458CVI	5 45 N	60 54	Jun 20	6.9	....	0 57 W	3	....	....	....	..	....	....	......	..	C1, D5	....	332	8	MS	bcs
459CVI	6 34 N	60 37	Do.	....	....	....	..	14.2	....	3 24 S	1	14.2	....	0.3611	2	D5	189.1234†	332	14	M	bc
460CVI	6 57 N	60 26	Do.	17.5	....	1 07 W	3	....	....	....	..	....	....	......	..	C1, D5	....	332	17	M	bc
461CVI	8 32 N	59 43	Jun 21	6.3	....	0 35 W	3	....	....	....	..	....	....	......	..	C1, D5	....	332	9	MC	bc
462CVI	9 43 N	59 20	Do.	....	....	....	..	14.7	....	3 41 N	2	14.7	....	.3643	2	D5	189.1234†	343	17	C	bc
463CVI	10 02 N	59 16	Do.	16.4	....	0 23 W	2	....	....	....	..	....	....	......	..	C1, D5	....	343	14	MRC	bc
464CVI	10 18 N	59 14	Do.	18.0	....	0 15 W	3	....	....	....	..	....	....	......	..	C1, D5	....	343	14	MRC	bc
465CVI	12 10 N	58 54	Jun 22	6.2	....	0 09 E	2	....	....	....	..	....	....	......	..	C1, D5	....	343	15	R	bcqz
466CVI	12 24 N	58 52	Do.	8.0	....	0 10 E	2	....	....	....	..	....	....	......	..	C1, D5	....	332	18	RH	bcs
467CVI	12 52 N	59 18	Do.	12.3	....	0 19 E	2	....	....	....	..	....	....	......	..	C1	....	45	16	R	bc
468CVI	13 03 N	59 32	Do.	....	....	....	..	14.2	....	11 23 N	2	14.2	....	.3649	2	D5	189.1234†	45	12	RH	bc
469CVI	13 20 N	59 56	Do.	17.3	....	0 13 E	2	....	....	....	..	....	....	......	..	C1, D5	....	68	11	RH	bcs
470CVI	12 41 N	61 58	Jun 23	6.5	....	0 13 W	2	....	....	....	..	....	....	......	..	C1, D5	....	112	24	RH	bcqz
471CVI	12 18 N	63 10	Do.	....	....	....	..	14.4	....	10 10 N	1	14.4	....	.3672	2	D5	189.1234†	112	17	R	bc
472CVI	12 07 N	63 35	Do.	17.4	....	0 26 W	2	....	....	....	..	....	....	......	..	C1, D5	....	118	20	R	bc
473CVI	11 25 N	65 12	Jun 24	6.2	....	0 49 W	3	....	....	....	..	....	....	......	..	C1, D5	....	118	18	R	bc
474CVI	10 55 N	66 20	Do.	....	....	....	..	14.1	....	7 04 N	2	14.1	....	.3720	2	D5	189.1234	118	10	MR	bc
475CVI	10 41 N	66 46	Do.	17.3	....	1 11 W	3	....	....	....	..	....	....	......	..	C1, D5	....	118	10	HC	bc
476CVI	9 56 N	68 23	Jun 25	7.0	....	1 23 W	3	....	....	....	..	....	....	......	..	C1, D5	....	118	8	M	bc
477CVI	9 34 N	69 14	Do.	....	....	....	..	14.5	....	3 27 N	2	14.5	....	.3754	2	D5	189.1234†	112	13	M	cqr
478CVI	9 29 N	69 27	Do.	16.5	....	1 50 W	2	....	....	....	..	....	....	......	..	C1	....	101	13	M	c
479CVI	8 48 N	71 09	Jun 26	7.9	....	2 00 W	2	....	....	....	..	....	....	......	..	C1, D5	....	135	8	M	cr
480CVI	8 35 N	71 50	Do.	....	....	....	..	14.3	....	1 01 N	3	14.3	....	.3775	3	D5	189.1234†	107	20	M	cr
481CVI	8 31 N	72 02	Do.	16.3	....	2 20 W	2	....	....	....	..	....	....	......	..	C1	....	107	14	M	c
482CVI	8 09 N	73 35	Jun 27	8.5	....	2 23 W	1	....	....	....	..	....	....	......	..	C1	....	146	8	SL	c
483CVI	8 03 N	74 03	Do.	....	....	....	..	14.4	....	0 23 S	3	14.4	....	.3780	3	D5	189.1234†	101	10	SL	c
484CVI	7 46 N	75 08	Jun 28	6.6	....	2 39 W	3	....	....	....	..	....	....	......	..	C1, D5	....	101,107	9	S	bc
485CVI	7 38 N	75 50	Do.	....	....	....	..	14.3	....	1 14 S	3	14.3	....	.3806	3	D5	189.1234	96	7	S	c
486CVI	7 37 N	76 11	Do.	17.0	....	2 12 W	3	....	....	....	..	....	....	......	..	C1, D5	....	68	8	MS	c
487CVI	7 30 N	78 06	Jun 29	7.1	....	2 13 W	2	....	....	....	..	....	....	......	..	C1	....	101	9	M	c
488CVI[1]	7 17 N	79 03	Do.	....	....	....	..	14.4	....	2 16 S	3	14.4	....	.3840	3	D5	189.1234†	129	16	ML	cqr
489CVI	6 36 N	79 50	Jul 24	17.0	....	2 47 W	2	....	....	....	..	....	....	......	..	C1	....	174	12	G	c
490CVI	5 01 N	80 04	Jul 25	8.3	....	2 57 W	2	....	....	....	..	....	....	......	..	C1	....	180	15	R	c
491CVI	4 36 N	80 26	Do.	....	....	....	..	14.3	....	9 28 S	3	14.3	....	.3807	3	D5	189.1234†	101	15	M	cqr
492CVI	4 34 N	80 50	Do.	17.4	....	3 08 W	3	....	....	....	..	....	....	......	..	C1, D5	....	101	13	M	c
493CVI	4 27 N	82 30	Jul 26	6.9	....	2 56 W	3	....	....	....	..	....	....	......	..	C1, D5	....	101	12	M	bc
494CVI	4 15 N	83 47	Do.	....	....	....	..	15.3	....	10 48 S	3	15.3	....	.3810	3	D5	EI7,189.1234†	112	11	M	bc
495CVI	4 09 N	84 04	Do.	17.3	....	3 17 W	2	....	....	....	..	....	....	......	..	C1, D5	....	101	11	M	c
496CVI	3 31 N	85 52	Jul 27	7.0	....	2 45 W	2	....	....	....	..	....	....	......	..	C1	....	112	16	M	c
497CVI	3 09 N	86 58	Do.	....	....	....	..	14.6	....	13 26 S	3	14.6	....	.3833	3	D5	EI7,189.1234†	112	14	M	bc
498CVI	3 02 N	87 22	Do.	17.2	....	2 49 W	3	....	....	....	..	....	....	......	..	C1, D5	....	118	12	M	bc
499CVI	2 25 N	89 13	Jul 28	7.2	....	2 41 W	3	....	....	....	..	....	....	......	..	C1, D5	....	112	8	M	c
500CVI	2 05 N	90 13	Do.	....	....	....	..	14.7	....	16 18 S	3	14.6	....	.3842	3	D5	EI7,189.1234†	112	6	M	c
501CVI	2 01 N	90 23	Do.	16.2	....	2 36 W	2	....	....	....	..	....	....	......	..	C1	....	124	6	M	c
502CVI	1 32 N	91 50	Jul 29	7.9	....	1 58 W	2	....	....	....	..	....	....	......	..	C1	....	34	6	S	c
503CVI	1 32 N	92 28	Do.	....	....	....	..	14.9	....	17 25 S	3	14.9	....	.3842	3	D5	EI7,189.1234†	79	7	MS	c
504CVI	1 15 N	93 07	Jul 30	7.4	....	1 55 W	3	....	....	....	..	....	....	......	..	C1, D5	....	124	8	S	cs
505CVI	0 59 N	93 28	Do.	....	....	....	..	14.5	....	18 50 S	3	14.5	....	.3831	3	D5	189.1234†	146	10	S	bc
506CVI	0 50 N	93 34	Do.	16.8	....	1 56 W	3	....	....	....	..	....	....	......	..	C1, D5	....	146	10	S	bc
507CVI	0 02 N	94 04	Jul 31	9.0	....	2 01 W	1	....	....	....	..	....	....	......	..	C1	....	146	14	SL	c
508CVI	0 20 S	94 03	Do.	....	....	....	..	14.4	....	21 36 S	3	14.4	....	.3797	3	D5	189.1234†	169	10	SL	c
509CVI	0 30 S	94 04	Do.	16.7	....	1 56 W	3	....	....	....	..	....	....	......	..	C1, D5	....	169	13	SL	bc
510CVI	1 55 S	94 07	Aug 1	....	....	....	..	14.5	....	25 09 S	3	14.5	....	.3738	3	D5	189.1234†	169	6	S	c
511CVI	2 01 S	94 07	Do.	16.0	....	2 09 W	2	....	....	....	..	....	....	......	..	C1, D5	....	169	6	S	c
512CVI	3 06 S	94 16	Aug 2	6.8	....	2 25 W	3	....	....	....	..	....	....	......	..	C1, D5	....	169	9	S	bc
513CVI	3 39 S	94 29	Do.	....	....	....	..	14.8	....	28 36 S	3	14.8	....	.3680	3	D5	189.1234†	146	7	S	bc

[1] From June 30 to July 24 the *Carnegie* was at Colombo, Ceylon.

FINAL RESULTS OF OCEAN MAGNETIC OBSERVATIONS ON THE CARNEGIE, 1915–1921—*Continued.*

CRUISE VI, INDIAN OCEAN, 1920—*Continued.*

Station	Lat.	Long. East of Gr.	Date	Declination L. M. T.		Declination Value	Wt.	Inclination L. M. T.		Inclination Value	Wt.	Hor. intensity L. M. T.		Hor. intensity Value	Wt.	Instruments Compass	Instruments Dip Circle	Remarks Course	Roll	Sea	Weather
	° ′	° ′	1920	h	h	° ′		h	h	° ′		h	h	c. g. s.				°	°		
514CVI	3 46 S	94 36	Aug 2	17.2	....	2 27 W	3	....	....	....	..	....	....	......	..	C1, D5	....	146	8	S	bc
515CVI	4 37 S	95 03	Aug 3	6.9	....	2 26 W	3	....	....	....	..	....	....	......	..	C1, D5	....	169	6	S	bc
516CVI	5 06 S	95 17	Do.	....	....	....	..	14.5	....	31 28 S	3	14.5	....	0.3619	3	D5	189.1234†	169	10	S	bc
517CVI	5 19 S	95 21	Do.	17.1	....	2 31 W	3	....	....	....	..	....	....	......	..	C1, D5	....	169	10	S	bc
518CVI	6 17 S	95 34	Aug 4	8.2	....	2 36 W	2	....	....	....	..	....	....	......	..	C1	....	169	10	S	o
519CVI	6 38 S	95 37	Do.	....	....	....	..	14.3	....	34 39 S	3	14.3	....	.3548	3	D5	189.1234†	180	9	S	ord
520CVI	6 50 S	95 37	Do.	17.2	....	2 40 W	3	....	....	....	..	....	....	......	..	C1, D5	....	180	7	S	bc
521CVI	7 43 S	95 36	Aug 5	6.7	....	2 53 W	3	....	....	....	..	....	....	......	..	C1, D5	....	180	6	SL	bc
522CVI	8 12 S	95 31	Do.	....	....	....	..	14.3	....	37 14 S	3	14.3	....	.3467	3	D5	189.1234†	214	10	SL	bc
523CVI	8 21 S	95 26	Do.	17.8	....	3 03 W	3	....	....	....	..	....	....	......	..	C1, D5	....	214	8	SL	bc
524CVI	9 02 S	95 05	Aug 6	6.7	....	3 22 W	3	....	....	....	..	....	....	......	..	C1, D5	....	208	10	SL	bc
525CVI	9 27 S	94 53	Do.	....	....	....	..	14.3	....	39 26 S	3	14.3	....	.3401	3	D5	189.1234†	214	12	SL	bc
526CVI	9 36 S	94 48	Do.	16.9	....	3 36 W	3	....	....	....	..	....	....	......	..	C1, D5	....	214	9	SL	bc
527CVI	10 16 S	94 23	Aug 7	7.6	....	4 01 W	2	....	....	....	..	....	....	......	..	C1, D5	....	208	13	SL	bc
528CVI	11 41 S	93 22	Aug 8	7.6	....	5 00 W	2	....	....	....	..	....	....	......	..	C1, D5	....	214	11	M	o
529CVI	12 22 S	92 55	Do.	....	....	....	..	14.4	....	44 22 S	2	14.4	....	.3212	2	D5	189.1234†	225	15	M	o
530CVI	14 11 S	91 07	Aug 9	7.6	....	7 01 W	2	....	....	....	..	....	....	......	..	C1, D5	....	225	14	M	bc
531CVI	14 56 S	90 24	Do.	....	....	....	..	14.3	....	48 09 S	1	14.3	....	.3043	1	D5	189.1234†	225	16	R	bcs
532CVI	15 12 S	90 10	Do.	16.6	....	7 50 W	2	....	....	....	..	....	....	......	..	C1, D5	....	225	12	MR	bc
533CVI	16 53 S	88 30	Aug 10	7.3	....	9 30 W	2	....	....	....	..	....	....	......	..	C1, D5	....	225	13	MR	bc
534CVI	17 44 S	87 45	Do.	....	....	....	..	15.0	....	51 30 S	1	15.0	....	.2852	1	D5	EI3,189.1234†	225	15	MR	bc
535CVI	17 56 S	87 35	Do.	16.8	....	10 13 W	1	....	....	....	..	....	....	......	..	C1, D5	....	225	12	R	bc
536CVI	19 32 S	86 04	Aug 11	7.1	....	11 52 W	2	....	....	....	..	....	....	......	..	C1, D5	....	225	14	MR	bc
537CVI	20 24 S	85 26	Do.	....	....	....	..	14.7	....	54 20 S	2	14.7	....	.2668	2	D5	EI3,189.1234†	214	14	MR	bc
538CVI	20 33 S	85 22	Do.	16.6	....	13 01 W	1	....	....	....	..	....	....	......	..	C1, D5	....	191	15	M	c
539CVI	21 58 S	84 02	Aug 12	7.2	....	14 09 W	2	....	....	....	..	....	....	......	..	C1, D5	....	225	11	M	bc
540CVI	22 38 S	83 20	Do.	....	....	....	..	14.7	....	56 30 S	2	14.7	....	.2511	2	D5	EI3,189.1234†	236	12	M	bc
541CVI	22 48 S	83 10	Do.	16.8	....	14 47 W	2	....	....	....	..	....	....	......	..	C1, D5	....	228	12	M	bc
542CVI	24 05 S	82 03	Aug 13	7.2	....	16 24 W	2	....	....	....	..	....	....	......	..	C1, D5	....	236	17	C	bc
543CVI	24 39 S	81 22	Do.	....	....	....	..	15.1	....	58 38 S	2	15.1	....	.2396	2	D5	EI3,189.1234†	242	9	MR	bc
544CVI	24 48 S	81 10	Do.	16.7	....	17 16 W	3	....	....	....	..	....	....	......	..	C1, D5	....	236	10	M	bc
545CVI	25 54 S	79 39	Aug 14	8.0	....	18 12 W	3	....	....	....	..	....	....	......	..	C1, D5	....	242	8	S	bc
546CVI	26 15 S	79 08	Do.	....	....	....	..	14.6	....	59 37 S	3	14.6	....	.2281	3	D5	EI3,189.1234†	267	9	S	bc
547CVI	26 20 S	78 58	Do.	16.8	....	18 51 W	3	....	....	....	..	....	....	......	..	C1, D5	....	264	9	S	bc
548CVI	25 39 S	80 15	Aug 15	7.5	....	18 37 W	3	....	....	....	..	....	....	......	..	C1, D5	....	68	12	M	bc
549CVI	26 55 S	78 27	Aug 16	7.4	....	19 37 W	2	....	....	....	..	....	....	......	..	C1, D5	....	248	9	C	bc
550CVI	27 13 S	77 56	Do.	....	....	....	..	14.6	....	60 02 S	3	14.6	....	.2234	3	D5	EI3,189.1234†	259	15	MC	o
551CVI	27 18 S	77 46	Do.	17.0	....	19 46 W	1	....	....	....	..	....	....	......	..	C1	....	259	16	C	o
552CVI	27 55 S	76 56	Aug 17	7.2	....	20 34 W	3	....	....	....	..	....	....	......	..	C1, D5	....	236	9	S	bc
553CVI	28 13 S	76 28	Do.	....	....	....	..	14.7	....	60 37 S	3	14.7	....	.2171	3	D5	EI3,189.1234†	Var.253	8	MS	bc
554CVI	28 16 S	76 24	Do.	15.6	....	20 52 W	3	....	....	....	..	....	....	......	..	C1, D5	....	248	8	MS	bc
555CVI	29 05 S	75 18	Aug 18	7.9	....	20 50 W	3	....	....	....	..	....	....	......	..	C1, D5	....	259	7	S	bc
556CVI	29 26 S	74 51	Do.	....	....	....	..	14.6	....	61 04 S	3	14.6	....	.2122	3	D5	EI3,189.1234†	236	8	S	bc
557CVI	29 39 S	74 37	Do.	17.5	....	22 23 W	2	....	....	....	..	....	....	......	..	C1	....	248	8	S	o
558CVI	30 41 S	74 05	Aug 19	....	....	....	..	14.7	....	61 53 S	3	14.7	....	.2070	3	D5	EI3,189.1234†	202	6	S	bc
559CVI	30 53 S	74 04	Do.	16.8	....	23 10 W	3	....	....	....	..	....	....	......	..	C1, D5	....	194	6	S	b
560CVI	32 18 S	75 40	Aug 20	10.2	....	24 55 W	2	....	....	....	..	....	....	......	..	C1	....	152	5	S	o
561CVI	32 43 S	76 06	Do.	....	....	....	..	14.7	....	63 18 S	3	14.7	....	.2032	3	D5	EI3,189.1234†	158	8	MS	bc
562CVI	32 55 S	76 22	Do.	16.7	....	25 07 W	3	....	....	....	..	....	....	......	..	C1, D5	....	163	8	S	bc

CRUISE VI, INDIAN OCEAN, 1920—*Concluded.*

	° ′	° ′	1920	h	h	° ′		h	h	° ′		h	h	c.g.s.				°	°		
563CVI	33 38 S	78 41	Aug 21	7.7	....	25 32 W	3	....	....	....	..	....	....	......	..	C1, D5	....	124	10	M	c
564CVI	33 50 S	79 47	Do.	....	....	....	..	14.9	....	64 41 S	3	14.9	....	0.2029	3	D5	EI3,189.1234†	124	7	M	b
565CVI	33 54 S	80 05	Do.	16.7	....	26 35 W	3	....	....	....	..	....	....	......	..	C1, D5	....	124	8	M	b
566CVI	34 27 S	82 40	Aug 22	7.8	....	26 16 W	3	....	....	....	..	....	....	......	..	C1, D5	....	141,129	8	MS	b
567CVI	34 44 S	83 50	Do.	....	....	....	..	14.9	....	65 44 S	2	14.9	....	.1991	2	D5	EI3,189.1234†	124	7	M	cd
568CVI	34 45 S	84 06	Do.	16.6	....	26 07 W	2	....	....	....	..	....	....	......	..	C1, D5	....	118	9	M	cd
569CVI	35 01 S	86 23	Aug 23	7.2	....	25 31 W	3	....	....	....	..	....	....	......	..	C1, D5	....	118	7	S	bc
570CVI	35 07 S	87 37	Do.	....	....	....	..	14.6	....	66 42 S	2	14.6	....	.2005	2	D5	EI3,189.1234†	112	8	S	cf
571CVI	35 08 S	87 50	Do.	16.0	....	25 40 W	2	....	....	....	..	....	....	......	..	C1	....	112	8	S	c
572CVI	35 15 S	90 38	Aug 24	7.0	....	24 44 W	2	....	....	....	..	....	....	......	..	C1, D5	....	112	11	MC	c
573CVI	35 16 S	90 58	Do.	8.7	....	23 58 W	2	....	....	....	..	....	....	......	..	C1	....	112	11	C	bc
574CVI	35 23 S	92 12	Do.	....	....	....	..	15.6	....	67 37 S	1	15.4	....	.2013	1	D5	EI3,189.1234†	118	29	R	cr
575CVI	35 27 S	92 54	Do.	19.4	....	23 33 W	2	....	....	....	..	....	....	......	..	C1	....	118	15	R	bc
576CVI	35 37 S	94 48	Aug 25	7.4	....	21 56 W	2	....	....	....	..	....	....	......	..	C1, D5	....	124	14	R	bc
577CVI	35 48 S	95 49	Do.	....	....	....	..	15.0	....	68 14 S	2	15.0	....	.2015	2	D5	EI3,189.1234†	129	20	R	bc
578CVI	35 52 S	96 03	Do.	16.7	....	21 50 W	2	....	....	....	..	....	....	......	..	C1, D5	....	124	20	M	bc
579CVI	35 39 S	98 28	Aug 26	7.2	....	19 53 W	2	....	....	....	..	....	....	......	..	C1, D5	....	107	22	ML	bc
580CVI	35 26 S	99 45	Do.	....	....	....	..	14.5	....	68 19 S	2	14.5	....	.2042	2	D5	EI3,189.1234†	96	15	MR	bc
581CVI	35 08 S	102 11	Aug 27	7.0	....	16 14 W	2	....	....	....	..	....	....	......	..	C1, D5	....	129	19	MLR	bc
582CVI	35 00 S	103 20	Do.	....	....	....	..	14.7	....	68 10 S	2	14.7	....	.2077	2	D5	EI3,189.1234†	96	14	ML	bc
583CVI	34 56 S	103 33	Do.	16.3	....	15 37 W	2	....	....	....	..	....	....	......	..	C1, D5	....	68	16	ML	bc
584CVI	34 42 S	105 58	Aug 28	7.0	....	13 07 W	2	....	....	....	..	....	....	......	..	C1, D5	....	107	13	MLR	cq
585CVI	34 33 S	107 24	Do.	....	....	....	..	14.9	....	68 19 S	1	14.9	....	.2112	1	D5	EI3,189.1234†	79	22	HR	bc
586CVI	34 29 S	107 41	Do.	16.9	....	12 19 W	2	....	....	....	..	....	....	......	..	C1, D5	....	84	18	R	bcq
587CVI	33 41 S	110 27	Aug 29	....	....	....	..	14.5	....	67 22 S	1	14.5	....	.2238	1	D5	189.1234†	68	13	R	c
588CVI	33 36 S	110 39	Do.	15.8	....	9 20 W	1	....	....	....	..	....	....	......	..	C1, D5	....	68	20	HR	bc
589CVI	32 32 S	112 38	Aug 30	7.0	....	6 37 W	2	....	....	....	..	....	....	......	..	C1, D5	....	62	16	R	bc
590CVI	32 18 S	113 25	Do.	....	....	....	..	14.3	....	65 45 S	1	14.3	....	.2350	1	D5	189.1234†	90	40	R	bc
591CVI[1]	32 16 S	113 41	Do.	16.6	....	6 06 W	2	....	....	....	..	....	....	......	..	C1, D5	....	90	17	R	bc
592CVI	32 12 S	115 20	Oct 1	17.0	....	4 53 W	3	....	....	....	..	....	....	......	..	C1, D5	....	202	5	S	bc
593CVI	33 09 S	114 43	Oct 2	6.1	....	4 52 W	2	....	....	....	..	....	....	......	..	C1, D5	....	197	10	M	bc
594CVI	35 15 S	115 57	Oct 3	6.3	....	6 21 W	2	....	....	....	..	....	....	......	..	C1, D5	....	146	15	ML	bc
595CVI	35 24 S	116 14	Do.	....	....	....	..	14.2	....	68 41 S	2	14.2	....	.2148	2	D5	189.1234†	158	17	LG	bc
596CVI	35 27 S	116 19	Do.	17.1	....	6 55 W	2	....	....	....	..	....	....	......	..	C1, D5	....	158	14	ML	bc
597CVI	36 42 S	116 56	Oct 4	6.8	....	7 20 W	2	....	....	....	..	....	....	......	..	C1, D5	....	158	18	MH	c
598CVI	37 50 S	117 42	Do.	....	....	....	..	15.2	....	70 08 S	2	15.2	....	.2011	2	D5	EI3,189.1234†	158	15	MR	bc
599CVI	38 05 S	117 52	Do.	17.2	....	7 40 W	2	....	....	....	..	....	....	......	..	C1, D5	....	158	18	R	bc
600CVI	39 50 S	119 07	Oct 5	6.0	....	7 53 W	2	....	....	....	..	....	....	......	..	C1	....	158	20	R	c
601CVI	41 01 S	119 58	Do.	....	....	....	..	14.5	....	72 37 S	2	14.5	....	.1842	2	D5	EI3,189.1234†	158	15	R	cs
602CVI	41 19 S	120 10	Do.	16.5	....	8 11 W	2	....	....	....	..	....	....	......	..	C1	....	158	15	R	cs
603CVI	42 52 S	121 08	Oct 6	6.8	....	8 38 W	2	....	....	....	..	....	....	......	..	C1, D5	....	158	20	HR	bc
604CVI	43 21 S	122 10	Do.	....	....	....	..	14.5	....	74 26 S	2	14.5	....	.1670	2	D5	EI3,189.1234†	124	24	R	bcq
605CVI	43 24 S	122 21	Do.	15.7	....	8 02 W	2	....	....	....	..	....	....	......	..	C1, D5	....	124	19	R	cs
606CVI	44 18 S	125 12	Oct 7	7.2	....	6 13 W	1	....	....	....	..	....	....	......	..	C1	....	112	18	R	c
607CVI	44 30 S	126 25	Do.	....	....	....	..	14.6	....	74 41 S	1	14.6	....	.1670	1	D5	EI3,189.1234†	112	21	R	bcq
608CVI	44 30 S	126 26	Do.	14.7	....	4 14 W	1	....	....	....	..	....	....	......	..	C1	....	112	21	R	bcq
609CVI	44 56 S	127 47	Oct 8	....	....	....	..	14.6	....	75 05 S	3	14.6	....	.1614	3	D5	EI3,189.1234†	135	11	M	c
610CVI	44 58 S	127 51	Do.	15.1	....	4 06 W	3	....	....	....	..	....	....	......	..	C1, D5	....	104	12	MS	bc
611CVI	45 05 S	128 00	Do.	16.8	....	4 22 W	3	....	....	....	..	....	....	......	..	C1, D5	....	135	13	MS	bc
612CVI	46 08 S	129 32	Oct 9	6.4	....	3 14 W	3	....	....	....	..	....	....	......	..	C1, D5	....	135	12	MS	c
613CVI	46 51 S	130 41	Do.	....	....	....	..	13.8	....	76 43 S	2	13.9	....	.1496	2	D5	189.1234	124	8	S	bc
614CVI	48 31 S	134 17	Oct 10	8.8	....	0 00	1	....	....	....	..	....	....	......	..	C1	....	124	14	M	cm
615CVI	48 55 S	135 18	Do.	....	....	....	..	14.5	....	77 08 S	3	14.5	....	.1439	3	D5	EI3,189.1234	112	25	MH	cr
616CVI	49 46 S	137 55	Oct 11	7.0	....	2 26 E	2	....	....	....	..	....	....	......	..	C1	....	118	12	M	c
617CVI	49 49 S	138 02	Do.	8.1	....	2 11 E	2	....	....	....	..	....	....	......	..	D5	....	112	20	M	bc
618CVI	50 02 S	139 10	Do.	....	....	....	..	14.6	....	77 58 S	2	14.5	....	.1378	2	D5	EI3,189.1234†	90	11	M	c
619CVI	50 03 S	139 22	Do.	15.3	....	3 22 E	2	....	....	....	..	....	....	......	..	C1	....	90	11	M	c
620CVI	50 20 S	142 25	Oct 12	6.5	....	6 46 E	2	....	....	....	..	....	....	......	..	C1	....	68	22	R	bcq
621CVI	50 21 S	144 08	Do.	....	....	....	..	14.6	....	77 37 S	1	14.6	....	.1393	1	D5	EI3,189.1234	73	13	RH	c
622CVI	50 20 S	144 22	Do.	15.9	....	8 12 E	2	....	....	....	..	....	....	......	..	C1	....	68	13	R	c

[1] From August 31 to October 1 the Carnegie was at Fremantle.

FINAL RESULTS OF OCEAN MAGNETIC OBSERVATIONS ON THE CARNEGIE, 1915–1921—*Continued.*

CRUISE VI, PACIFIC OCEAN, 1920–1921.

Station	Lat.	Long. East of Gr.	Date	Declination L. M. T.		Declination Value	Declination Wt.	Inclination L. M. T.		Inclination Value	Inclination Wt.	Hor. intensity L. M. T.		Hor. intensity Value	Hor. intensity Wt.	Instruments Compass	Instruments Dip Circle	Remarks Course	Remarks Roll	Remarks Sea	Remarks Weather
	° ′	° ′	1920	h	h	° ′		h	h	° ′		h	h	c. g. s.				°	°		
623CVI	50 30 S	147 05	Oct 13	6.8		10 21 E	1									C1, D5		90	25	HR	c
624CVI	50 35 S	148 31	Do.					13.8		77 44 S	1	13.9		0.1416	1	D5	189.234	79	22	H	bc
625CVI	50 34 S	148 52	Do.	15.8		12 01 E	1									C1, D5		56	22	RH	bc
626CVI	49 56 S	151 09	Oct 14	6.0		13 04 E	2									C1, D5		56	12	R	cq
627CVI	49 38 S	152 36	Do.					14.5		75 56 S	1	14.5		.1554	1	D5	EI3,189.1234†	34	32	HR	bcq
628CVI	49 31 S	152 53	Do.	16.2		13 45 E	2									C1, D5		34	18	HR	bcq
629CVI	47 58 S	156 16	Oct 15					14.4		74 09 S	2	14.4		.1733	2	D5	EI3,189.1234†	68	15	R	cqr
630CVI	47 56 S	156 36	Do.	15.9		14 31 E	1									C1, D5		68	15	R	cq
631CVI	47 34 S	160 36	Oct 16					14.4		73 07 S	2	14.4		.1828	2	D5	EI3,189.1234†	90	20	R	c
632CVI	47 38 S	160 56	Do.	16.1		16 07 E	2									C1, D5		101	20	R	c
633CVI	47 59 S	163 46	Oct 17	7.4		16 55 E	1									C1		84,118	18	M	c
634CVI	48 00 S	165 24	Do.					14.6		72 55 S	1	14.6		.1846	2	D5	189.1234†	73	11	M	cq
635CVI	47 59 S	165 53	Do.	17.1		18 22 E	2									C1, D5		68	18	M	c
636CVI	47 44 S	168 28	Oct 18	5.4		18 23 E	2									C1		28	22	R	bcq
637CVI	47 34 S	168 43	Do.	7.2		18 18 E	2									C1, D5		349	23	MR	cqr
638CVI	46 42 S	169 54	Do.					14.2		70 52 S	3	14.2		.2039	3	D5	189.1234†	17	16	M	bc
639CVI	46 18 S	170 17	Do.	17.1		18 10 E	3									C1, D5		17	6	MS	bc
640CVI	45 41 S	171 12	Oct 19	5.9		18 00 E	3									C1, D5		34	7	S	bc
641CVI	45 22 S	171 38	Do.					14.1		69 47 S	3	14.1		.2099	3	D5	189.1234†	68,79	6	S	bc
642CVI	45 18 S	171 46	Do.	16.2		17 58 E	3									C1, D5		6	6	S	bc
643CVI	44 42 S	172 30	Oct 20	6.5		17 33 E	3									C1, D5		28	6	S	bc
644CVI	44 25 S	172 51	Do.					13.2		68 41 S	3	13.2		.2187	3	D5	189.234	0	6	S	bc
645CVI[1]	44 16 S	173 03	Do.	17.3		17 38 E	3									C1, D5		11	5	S	bc
646CVI	43 29 S	173 09	Nov 19	17.7		17 19 E	3									C1, D5		45	6	S	bc
647CVI	44 20 S	174 46	Nov 20	6.2		17 40 E	2									C1		101	16	M	c
648CVI	44 51 S	175 50	Do.					14.3		69 05 S	3	14.3		.2161	3	D5	189.1234†	101	14	M	c
649CVI	44 59 S	176 13	Do.	17.7		18 08 E	3									C1, D5		84	14	M	bc
650CVI	44 49 S	176 43	Nov 21	7.6		18 07 E	1									C1		326	14	SL	fs
651CVI	45 08 S	177 00	Do.					14.6		68 28 S	3	14.6		.2198	3	D5	EI3,189.1234†	135	10	S	mf
652CVI	46 01 S	177 31	Nov 22	6.6		18 38 E	3									C1, D5		101	10	SL	bc
653CVI	46 09 S	178 51	Do.					14.4		69 44 S	2	14.4		.2153	2	D5	189.1234†	73	20	R	or
654CVI[2]	46 11 S	181 55	Do.	8.0		18 58 E	1									C1		112	20	R	c
655CVI	46 14 S	183 10	Do.					14.6		68 25 S	2	14.6		.2195	2	D5	EI3,189.1234†	68	27	MR	bc
656CVI	46 15 S	183 43	Do.	17.8		19 09 E	2									C1, D5		68	16	RL	bc
657CVI	46 23 S	185 58	Nov 23	6.6		19 18 E	3									C1, D5		112	20	MR	bc
658CVI	46 24 S	187 40	Do.					14.6		67 58 S	3	14.6		.2216	3	D5	EI3,189.1234	68	10	MR	bc
659CVI	46 23 S	188 20	Do.	18.0		19 10 E	2									C1, D5		68	17	R	bc
660CVI	46 25 S	189 43	Nov 24	7.5		18 37 E	1									C1		112	10	SL	c
661CVI	46 31 S	190 42	Do.					14.8		67 17 S	3	14.8		.2256	3	D5	EI3,189.1234†	68	7	S	ofr
662CVI	46 33 S	191 16	Do.	17.6		19 25 E	3									C1, D5		84	13	MS	cs
663CVI	46 40 S	193 48	Nov 25	5.2		19 07 E	2									C1		68	12	S	c
664CVI	46 44 S	195 27	Do.					13.9		66 40 S	3	13.9		.2308	3	D5	189.234	68	13	SL	of
665CVI	46 44 S	200 16	Nov 26					14.5		66 05 S	3	14.5		.2321	3	D5	EI3,189.1234†	68	7	M	of
666CVI	46 51 S	203 20	Nov 27	6.3		20 05 E	2									C1		124	10	M	c
667CVI	46 39 S	205 04	Do.					14.8		65 22 S	2	14.8		.2347	2	D5	EI3,189.1,2,11,12†	37	12	M	or
668CVI	45 41 S	207 26	Nov 28	6.7		18 47 E	2									C1		62	27	M	c
669CVI	45 25 S	207 55	Do.					14.7		63 31 S	3	14.7		.2470	3	D5	EI3,189.1,2,11,12†	34	15	MS	c
670CVI	45 18 S	208 07	Do.	16.8		18 23 E	2									C1, D5		34	10	ML	bc

[1] From October 21 to November 19 the *Carnegie* was at Lyttelton. [2] Crossed 180th meridian; hence date November 22 repeated.

CRUISE VI, PACIFIC OCEAN, 1920–1921—*Continued.*

	° ′	° ′	*1920*	*h*	*h*	° ′		*h*	*h*	° ′		*h*	*h*	*c. g. s.*				°	°		
671CVI	44 32 S	209 14	Nov 29	6.6		18 12 E	2									C1, D5		34	9	MS	bc
672CVI	43 58 S	210 10	Do.					14.8		62 04 S	3	14.8		0.2541	3	D5	EI3,189.1,2,*11,12*†	34,45	15	M	bc
673CVI	43 48 S	210 31	Do.	17.2		18 13 E	3									C1, D5		34	25	ML	bc
674CVI	43 23 S	211 28	Nov 30	5.0		17 35 E	2									C1, D5		45	24	SL	b
675CVI	43 28 S	212 07	Do.					15.0		61 44 S	3	15.0		.2558	3	D5	189.1,2,*11,12*†	87	13	ML	bc
676CVI	43 31 S	212 22	Do.	16.6		17 26 E	2									C1, D5		96	5	ML	bcs
677CVI	43 32 S	212 30	Do.	17.3		17 47 E	2									D5		96	7	M	bc
678CVI	43 21 S	216 15	Dec 1					14.1		61 02 S	2	14.1		.2592	2	D5	189.1,2,*11,12*†	22	23	CR	qro
679CVI	43 13 S	216 21	Do.	17.6		17 46 E	3									C1, D5		354	9	MR	bc
680CVI	42 10 S	217 09	Dec 2	5.8		17 37 E	2									C1		11	6	SL	cz
681CVI	41 23 S	217 56	Do.					14.8		58 56 S	3	14.8		.2683	3	D5	EI3,189.1,2,*11,12*†	11	9	MS	b
682CVI	41 05 S	218 08	Do.	17.6		17 20 E	3									C1, D5		6	6	S	bc
683CVI	40 03 S	218 54	Dec 3	6.5		17 01 E	3									C1, D5		8	11	SL	bc
684CVI	39 10 S	219 48	Do.					14.7		56 32 S	3	14.7		.2765	3	D5	EI3,189.1,2,*11,12*†	17	12	SL	bc
685CVI	38 53 S	220 06	Do.	17.0		16 13 E	2									C1		20	12	SL	c
686CVI	37 53 S	221 41	Dec 4	5.3		15 41 E	3									C1, D5		31	7	S	c
687CVI	37 09 S	222 50	Do.					14.8		53 51 S	3	14.8		.2861	3	D5	EI3,189.1,2,*11,12*†	28	9	S	c
688CVI	37 03 S	223 03	Do.	16.5		15 49 E	2									C1, D5		34	7	S	c
689CVI	36 18 S	224 37	Dec 5	5.1		15 29 E	3									C1, D5		51	8	S	bc
690CVI	36 18 S	225 29	Do.					14.8		52 50 S	3	14.8		.2870	3	D5	EI3,189.1,2,*11,12*†	233	10	M	c
691CVI	36 18 S	225 31	Do.	17.4		15 29 E	2									C1, D5		45	10	M	c
692CVI	35 20 S	226 24	Dec 6	5.2		15 33 E	3									C1, D5		0	25	R	bc
693CVI	34 38 S	227 03	Do.					14.4		50 38 S	1	14.4		.2908	2	D5	189.1,2,*11,12*†	17	19	M	bc
694CVI	34 16 S	227 22	Do.	17.5		14 38 E	2									C1, D5		17	12	RL	bc
695CVI	33 27 S	227 32	Dec 7	5.2		14 50 E	2									C1, D5		338	20	SL	bc
696CVI	33 06 S	227 28	Do.					14.3		49 08 S	3	14.3		.2950	3	D5	189.1,2,*11,12*†	304	14	L	bc
697CVI	32 56 S	227 22	Do.	17.7		14 47 E	3									C1, D5		349	18	SL	bc
698CVI	32 04 S	227 44	Dec 8					15.0		48 06 S	3	15.0		.2979	3	D5	EI3,189.1,2,*11,12*†	22	10	SL	bc
699CVI	31 58 S	227 50	Do.	17.6		14 20 E	3									C1, D5		8	12	SL	bc
700CVI	30 51 S	228 20	Dec 9					14.7		46 17 S	3	14.7		.3014	3	D5	EI3,189.1,2,*11,12*†	17	5	S	bc
701CVI	30 45 S	228 28	Do.	17.5		14 03 E	3									C1, D5		39	7	S	bc
702CVI	30 13 S	228 29	Dec 10					14.9		45 10 S	3	14.9		.3041	3	D5	EI3,189.1,2,*11,12*†	45	8	S	bc
703CVI	30 09 S	228 39	Do.	17.6		13 27 E	3									C1, D5		264	6	S	bc
704CVI	30 06 S	227 28	Dec 11					14.6		45 37 S	2	14.6		.3024	2	D5	EI3,189.1,2,*11,12*†	292	14	C	bc
705CVI	30 04 S	227 25	Do.	17.3		13 30 E	2									C1, D5		292	14	MC	c
706CVI	29 19 S	225 53	Dec 12					14.7		45 08 S	2	14.7		.3044	2	D5	EI3,189.1,2,*11,12*†	298	15	L	bc
707CVI	29 07 S	225 42	Do.	17.3		13 18 E	2									C1, D5		321	24	L	bc
708CVI	28 23 S	224 38	Dec 13	5.8		12 35 E	3									C1, D5		298	13	L	bc
709CVI	28 03 S	224 08	Do.					14.6		44 05 S	3	14.6		.3085	3	D5	EI3,189.1,2,*11,12*†	304	18	SL	bc
710CVI	28 01 S	224 04	Do.	17.5		12 56 E	3									C1, D5		304	18	SL	bc
711CVI	27 26 S	223 18	Dec 14	6.3		12 46 E	2									C1		298	7	S	c
712CVI	27 20 S	222 51	Do.					14.4		42 56 S	3	14.4		.3109	3	D5	EI3,189.1,2,*11,12*†	304	7	S	bc
713CVI	27 14 S	222 41	Do.	17.4		12 53 E	3									C1, D5		304	9	S	bc
714CVI	26 46 S	221 59	Dec 15	5.6		12 05 E	3									C1, D5		304	10	S	bc
715CVI	26 08 S	221 21	Do.					14.5		41 52 S	3	14.5		.3132	3	D5	EI3,189.1,2,*11,12*†	309	9	S	bc
716CVI	25 52 S	221 07	Do.	17.6		12 10 E	3									C1, D5		338	6	S	bc
717CVI	24 37 S	219 51	Dec 16	5.9		12 01 E	3									C1, D5		309	14	M	bc
718CVI	23 56 S	219 03	Do.					14.5		39 22 S	2	14.5		.3206	2	D5	EI3,189.1,2,*11,12*†	304	15	M	bc
719CVI	23 42 S	218 46	Do.	17.6		11 48 E	3									C1, D5		343	16	M	bcq
720CVI	22 42 S	217 35	Dec 17	5.9		11 43 E	3									C1, D5		304	13	M	bc
721CVI	22 05 S	216 45	Do.					14.8		37 11 S	3	14.8		.3216	3	D5	EI3,189.1,2,*11,12*†	304	15	M	bc
722CVI	21 54 S	216 31	Do.	17.6		11 24 E	3									C1, D5		304	13	M	bc
723CVI	21 11 S	215 34	Dec 18	5.8		11 14 E	3									C1, D5		304	10	M	bc
724CVI	20 43 S	214 55	Do.					14.6		35 25 S	3	14.6		.3261	3	D5	EI3,189.1,2,*11,12*†	298	9	S	bc
725CVI	20 34 S	214 46	Do.	17.6		11 05 E	3									C1, D5		309	9	S	bc
726CVI	19 47 S	214 00	Dec 19	5.9		10 52 E	3									C1, D5		309	8	S	bc
727CVI	19 25 S	213 25	Do.					14.7		34 01 S	3	14.7		.3294	3	D5	EI3,189.1,2,*11,12*†	298	5	S	c
728CVI	18 47 S	212 37	Dec 20	5.8		10 40 E	3									C1, D5		309	8	S	bc
729CVI	18 41 S	212 11	Do.					14.6		32 11 S	2	14.6		.3330	2	D5	EI3,189.1,2,*11,12*†	59	6	S	bc

FINAL RESULTS OF OCEAN MAGNETIC OBSERVATIONS ON THE CARNEGIE, 1915–1921—*Continued.*

CRUISE VI, PACIFIC OCEAN, 1920–1921—*Continued.*

Station	Lat.	Long. East of Gr.	Date	Declination L. M. T.		Declination Value	Declination Wt.	Inclination L. M. T.		Inclination Value	Inclination Wt.	Hor. intensity L. M. T.		Hor. intensity Value	Hor. intensity Wt.	Instruments Compass	Instruments Dip Circle	Remarks Course	Remarks Roll	Remarks Sea	Weather
	° ′	° ′	*1920*	h	h	° ′		h	h	° ′		h	h	c. g. s.				°	°		
730CVI	18 10 S	212 11	Dec 21	17.6		10 25 E	3									C1, D5		276	10	S	bc
731CVI	17 44 S	211 18	Dec 22					14.0		31 19 S	3	14.0		0.3343	3	D5	189.1,2,*11,12*†	287	10	S	bc
732CVI[1]	17 37 S	211 03	Do.	17.2		10 48 E	3									C1, D5		292	13	S	bc
			1921																		
733CVI	16 45 S	209 36	Jan 4	6.0		10 20 E	3									C1, D5		321	6	S	bc
734CVI	16 23 S	209 22	Do.					14.8		29 22 S	3	14.8		.3375	3	D5	EI3,189.1,2,*11,12*†	338	4	S	bc
735CVI	16 14 S	209 20	Do.	17.5		10 16 E	3									C1, D5		349	7	S	bc
736CVI	15 01 S	209 00	Jan 5	6.3		9 57 E	3									C1, D5		349	8	S	bc
737CVI	14 15 S	208 55	Do.					14.8		28 02 S	2	14.8		.3400	2	D5	EI3,189.1,2,*11,12*†	0	10	M	bc
738CVI	13 58 S	208 55	Do.	17.7		9 44 E	3									C1, D5		0	9	MS	bc
739CVI	12 37 S	208 53	Jan 6	6.3		9 40 E	3									C1, D5		349	8	MS	bc
740CVI	12 00 S	208 44	Do.					14.8		21 44 S	3	14.8		.3422	3	D5	EI3,189.1,2,*11,12*†	Var. 0	15	M	bcq
741CVI	11 48 S	208 43	Do.	17.2		9 14 E	2									C1		349	10	M	o
742CVI	10 53 S	208 16	Jan 7	7.5		9 12 E	2									C1		357	7	M	o
743CVI	10 14 S	208 12	Do.					14.8		18 40 S	3	14.8		.3440	3	D5	EI3,189.1,2,*11,12*†	343	11	M	o
744CVI	9 57 S	208 09	Do.	17.4		9 09 E	3									C1, D5		349	10	M	bc
745CVI	8 46 S	207 43	Jan 8	6.4		8 56 E	3									C1, D5		343	8	M	bc
746CVI	7 52 S	207 28	Do.					14.7		14 25 S	2	14.7		.3453	2	D5	EI3,189.1,2,*11,12*†	346	10	M	bc
747CVI	7 35 S	207 24	Do.	17.3		8 42 E	3									C1, D5		349	11	M	bc
748CVI	6 05 S	207 14	Jan 9	6.4		8 35 E	3									C1, D5		349	12	M	bc
749CVI	5 13 S	207 00	Do.					14.8		9 08 S	3	14.8		.3456	3	D5	EI3,189.1,2,*11,12*†	338	15	M	bc
750CVI	5 02 S	206 55	Do.	17.6		8 32 E	3									C1, D5		338	9	M	bc
751CVI	4 11 S	206 27	Jan 10	6.6		8 38 E	3									C1, D5		343	10	MS	bc
752CVI	3 20 S	205 52	Do.					14.8		4 59 S	3	14.8		.3459	3	D5	EI3,189.1,2,*11,12*†	332	12	S	bc
753CVI	3 04 S	205 42	Do.	17.5		8 19 E	3									C1, D5		338	10	MS	bc
754CVI	1 40 S	204 56	Jan 11	6.6		7 57 E	3									C1, D5		332	10	MS	bc
755CVI	0 37 S	204 40	Do.					14.8		0 55 N	3	14.8		.3461	3	D5	EI3,189.1,2,*11,12*†	349	9	S	bc
756CVI	0 12 S	204 35	Do.	17.6		8 04 E	3									C1, D5		349	8	MS	bc
757CVI	1 33 N	204 27	Jan 12	6.7		8 06 E	3									C1, D5		0	12	M	bc
758CVI	2 23 N	203 51	Do.					14.9		6 25 N	2	14.9		.3400	2	D5	EI3,189.1,2,*11,12*†	292	12	M	bc
759CVI	2 33 N	203 31	Do.	17.4		8 01 E	3									C1, D5		292	11	M	bc
760CVI	3 17 N	202 10	Jan 13	6.8		8 10 E	3									C1, D5		298	21	M	bc
761CVI	3 39 N	201 26	Do.					14.9		8 16 N	3	14.9		.3357	3	D5	EI3,189.1,2,*11,12*†	281	13	M	bc
762CVI	3 45 N	201 18	Do.	17.2		7 37 E	3									C1, D5		354	14	M	bc
763CVI[2]	4 00 N	200 36	Jan 14	17.3		8 14 E	3									C1, D5		349	14	MS	bc
764CVI	5 22 N	200 30	Jan 15	6.8		8 52 E	3									C1, D5		349	10	MS	bc
765CVI	6 08 N	200 23	Do.					14.8		13 24 N	3	14.8		.3325	3	D5	EI3,189.1,2,*11,12*†	349	10	S	bc
766CVI	6 26 N	200 20	Do.	17.3		8 02 E	3									C1, D5		349	13	S	bc
767CVI	7 50 N	200 07	Jan 16	7.0		8 11 E	3									C1, D5		343	10	M	bc
768CVI	8 39 N	200 06	Do.					14.7		18 34 N	2	14.7		.3227	2	D5	EI3,189.1,2,*11,12*†	349	10	M	bc
769CVI	8 57 N	200 06	Do.	17.3		8 34 E	3									C1, D5		349	9	M	bc
770CVI	10 27 N	199 42	Jan 17	7.7		8 56 E	2									C1		338	11	M	bc
771CVI	10 31 N	199 41	Do.	8.4		8 52 E	2									C1		332	10	M	bc
772CVI	11 13 N	199 30	Do.					14.8		22 49 N	2	14.8		.3199	2	D5	EI3,189.1,2,*11,12*†	338	16	M	bc
773CVI	11 30 N	199 25	Do.	17.1		8 37 E	2									C1, D5		338	10	M	cd
774CVI	13 22 N	198 47	Jan 18	8.4		9 11 E	2									C1		338	14	M	cd
775CVI	14 17 N	198 23	Do.					15.2		28 01 N	2	15.2		.3108	2	D5	EI3,189.1,2,*11,12*†	335	12	MR	or
776CVI	16 09 N	197 31	Jan 19	7.4		9 33 E	2									C1, D5		338	15	M	o

[1] Local disturbance near Tahiti? From December 23 to January 4 the *Carnegie* was at Papeete.

[2] On January 14 the *Carnegie* stopped for a few hours at Fanning Island.

CRUISE VI, PACIFIC OCEAN, 1920–1921—*Continued.*

	° ′	° ′	1921	h	h	° ′		h	h	° ′		h	h	c. g. s.				°	°		
777CVI	16 18 N	197 25	Jan 19	....	....	....	..	14.5	....	31 05 N	3	14.5	....	0.3040	3	D5	189.1,2,*11,12*†	315	20	ML	o
778CVI	16 26 N	197 18	Do.	16.5	....	9 36 E	2	....	....	....	..	....	....	......	..	C1	....	315	16	M	o
779CVI	17 21 N	196 23	Jan 20	7.4	....	10 01 E	3	....	....	....	..	....	....	......	..	C1, D5	....	315	13	ML	o
780CVI	17 42 N	196 07	Do.	....	....	....	..	14.9	....	32 44 N	3	14.9	....	.2992	3	D5	EI3,189.1,2,*11,12*†	326	12	S	o
781CVI	18 36 N	195 34	Jan 21	7.1	....	10 11 E	3	....	....	....	..	....	....	......	..	C1, D5	....	326	11	MS	cr
782CVI	19 18 N	195 12	Do.	....	....	....	..	14.8	....	34 29 N	3	14.8	....	.2956	3	D5	EI3,189.1,2,*11,12*†	315	12	M	bo
783CVI	19 26 N	195 08	Do.	16.3	....	10 11 E	3	....	....	....	..	....	....	......	..	C1, D5	....	315	18	M	bo
784CVI	20 49 N	194 22	Jan 22	7.3	....	10 24 E	3	....	....	....	..	....	....	......	..	C1, D5	....	315	18	MS	bo
785CVI	21 14 N	194 00	Do.	....	....	....	..	15.1	....	37 05 N	3	15.1	....	.2900	3	D5	EI3,189.1,2,*11,12*†	315	13	S	o
786CVI	22 10 N	192 28	Jan 23	7.6	....	10 35 E	2	....	....	....	..	....	....	......	..	C1	....	298	17	R	o
787CVI	22 32 N	191 56	Do.	....	....	....	..	14.9	....	38 07 N	3	14.9	....	.2874	3	D5	EI3,189.1,2,*11,12*†	292	18	ML	o
788CVI	22 37 N	191 50	Do.	16.3	....	10 44 E	3	....	....	....	..	....	....	......	..	C1, D5	....	292	14	M	bo
789CVI	23 02 N	191 08	Jan 24	7.2	....	10 43 E	3	....	....	....	..	....	....	......	..	C1, D5	....	292	14	SL	bo
790CVI	23 30 N	190 18	Do.	....	....	....	..	14.9	....	39 11 N	2	14.9	....	.2835	2	D5	EI3,189.1,2,*11,12*†	304	14	M	bo
791CVI	23 36 N	190 11	Do.	16.3	....	10 45 E	2	....	....	....	..	....	....	......	..	C1, D5	....	309	18	M	bo
792CVI	25 00 N	188 59	Jan 25	7.4	....	10 52 E	1	....	....	....	..	....	....	......	..	C1	....	315	20	R	cr
793CVI	25 36 N	188 26	Do.	....	....	....	..	15.1	....	41 14 N	2	15.1	....	.2775	2	D5	EI3,189.1,2,*11,12*†	304,315	17	M	bo
794CVI	25 41 N	188 21	Do.	16.5	....	10 35 E	2	....	....	....	..	....	....	......	..	C1, D5	....	304	17	M	bo
795CVI	26 47 N	187 37	Jan 26	7.3	....	10 50 E	3	....	....	....	..	....	....	......	..	C1, D5	....	321	17	S	bo
796CVI	27 26 N	187 17	Do.	....	....	....	..	14.9	....	42 50 N	3	14.9	....	.2745	3	D5	EI3,189.1,2,*11,12*†	321	12	S	bo
797CVI	27 44 N	187 14	Do.	18.2	....	10 40 E	2	....	....	....	..	....	....	......	..	C1	....	321	11	S	bo
798CVI	28 54 N	186 40	Jan 27	7.4	....	10 53 E	2	....	....	....	..	....	....	......	..	C1, D5	....	321	14	S	c
799CVI	29 11 N	186 33	Do.	....	....	....	..	14.8	....	44 17 N	3	14.7	....	.2728	3	D5	EI3,189.1,2,*11,12*†	315	13	S	bo
800CVI	29 20 N	186 27	Do.	16.7	....	10 52 E	3	....	....	....	..	....	....	......	..	C1, D5	....	315	10	S	bo
801CVI	30 52 N	185 59	Jan 28	8.3	....	10 48 E	2	....	....	....	..	....	....	......	..	C1	....	11	12	M	c
802CVI	31 32 N	186 42	Do.	....	....	....	..	15.2	....	47 02 N	2	15.2	....	.2661	2	D5	EI3,189.1,2,*11,12*†	22	17	M	bo
803CVI	31 39 N	186 50	Do.	16.6	....	11 07 E	2	....	....	....	..	....	....	......	..	C1, D5	....	34	16	ML	bo
804CVI	32 34 N	188 30	Jan 29	7.6	....	11 34 E	3	....	....	....	..	....	....	......	..	C1, D5	....	56	13	ML	bo
805CVI	32 36 N	188 56	Do.	....	....	....	..	14.8	....	48 23 N	3	14.8	....	.2636	3	D5	EI3,189.1,2,*11,12*†	34	12	SL	bo
806CVI	32 36 N	188 58	Do.	16.3	....	11 24 E	2	....	....	....	..	....	....	......	..	C1, D5	....	34	11	L	bo
807CVI	34 12 N	188 57	Jan 30	9.5	....	11 49 E	2	....	....	....	..	....	....	......	..	C1, D5	....	11	15	R	bo
808CVI	34 35 N	189 27	Do.	....	....	....	..	15.0	....	50 18 N	1	15.0	....	.2594	1	D5	EI3,189.1,2,*11,12*†	22	22	R	bo
809CVI	34 40 N	189 32	Do.	16.3	....	11 49 E	3	....	....	....	..	....	....	......	..	C1, D5	....	25	22	R	bo
810CVI	35 58 N	191 02	Jan 31	7.7	....	12 19 E	2	....	....	....	..	....	....	......	..	C1, D5	....	22	14	R	cq
811CVI	36 35 N	191 41	Do.	....	....	....	..	14.8	....	52 28 N	2	14.8	....	.2558	2	D5	EI3,189.1,2,*11,12*†	34	25	R	bo
812CVI	36 40 N	191 58	Do.	16.1	....	12 31 E	2	....	....	....	..	....	....	......	..	C1	....	34,22	15	R	o
813CVI	38 23 N	194 31	Feb 1	13.8	....	13 34 E	1	....	....	....	..	....	....	......	..	C1	....	68	14	R	o
814CVI	38 24 N	194 39	Do.	....	....	....	..	15.0	....	55 05 N	2	15.0	....	.2499	2	D5	EI3,189.1,2,*11,12*†	68	14	R	or
815CVI	38 36 N	195 05	Feb 2	7.9	....	14 01 E	3	....	....	....	..	....	....	......	..	C1, D5	....	68	16	RL	o
816CVI	38 36 N	195 10	Do.	8.7	....	13 35 E	3	....	....	....	..	....	....	......	..	D5	....	68	16	R	o
817CVI	38 43 N	196 08	Do.	....	....	....	..	14.8	....	55 29 N	2	14.8	....	.2484	2	D5	EI3,189.1,2,*11,12*†	68	15	M	or
818CVI	38 44 N	196 15	Do.	16.0	....	14 17 E	2	....	....	....	..	....	....	......	..	C1, D5	....	68	12	ML	c
819CVI	38 56 N	197 23	Feb 3	7.5	....	14 31 E	3	....	....	....	..	....	....	......	..	C1, D5	....	56	11	MS	b
820CVI	39 12 N	198 36	Do.	....	....	....	..	15.4	....	55 48 N	2	15.5	....	.2492	2	D5	EI3,189.1,2,*11,12*†	62	14	S	bo
821CVI	39 14 N	198 42	Do.	16.0	....	15 13 E	2	....	....	....	..	....	....	......	..	C1	....	56	14	S	bos
822CVI	40 01 N	201 29	Feb 4	10.5	....	16 36 E	1	....	....	....	..	....	....	......	..	C1	....	79	20	R	cm
823CVI	40 02 N	201 37	Do.	11.4	....	15 58 E	2	....	....	....	..	....	....	......	..	C1	....	79	20	R	cm
824CVI	40 01 N	202 08	Do.	....	....	....	..	14.9	....	57 34 N	2	14.9	....	.2448	2	D5	EI3,189.1,2,*11,12*†	90	17	R	cmf
825CVI	39 56 N	204 38	Feb 5	11.3	....	17 14 E	1	....	....	....	..	....	....	......	..	C1	....	79	10	M	cm
826CVI	39 54 N	205 28	Do.	....	....	....	..	15.6	....	57 49 N	1	15.6	....	.2455	1	D5	EI3,189.1,2,*11,12*†	79	15	M	cm
827CVI	40 05 N	209 03	Feb 6	13.5	....	17 53 E	1	....	....	....	..	....	....	......	..	C1	....	90	13	R	o
828CVI	40 04 N	209 10	Do.	....	....	....	..	14.9	....	58 26 N	1	14.9	....	.2460	1	D5	189.1,2,*11,12*†	90	30	R	o
829CVI	39 58 N	211 05	Feb 7	8.9	....	17 46 E	2	....	....	....	..	....	....	......	..	C1	....	78	8	SL	o
830CVI	39 58 N	211 10	Do.	9.6	....	18 11 E	2	....	....	....	..	....	....	......	..	C1, D5	....	84	8	SL	o
831CVI	39 54 N	211 58	Do.	....	....	....	..	15.3	....	58 55 N	2	15.3	....	.2460	2	D5	EI3,189.1,2,*11,12*†	84	12	S	of
832CVI	39 29 N	214 40	Feb 8	10.0	....	18 38 E	2	....	....	....	..	....	....	......	..	C1	....	84	20	R	cs
833CVI	39 24 N	215 17	Do.	....	....	....	..	15.2	....	58 56 N	2	15.2	....	.2472	2	D5	EI3,189.1,2,*11,12*†	90	20	R	of
834CVI	39 03 N	217 45	Feb 9	8.1	....	18 49 E	1	....	....	....	..	....	....	......	..	C1	....	68	14	R	cm
835CVI	39 04 N	217 58	Do.	9.4	....	18 55 E	2	....	....	....	..	....	....	......	..	C1, D5	....	56	14	R	cq

FINAL RESULTS OF OCEAN MAGNETIC OBSERVATIONS ON THE CARNEGIE, 1915–1921—*Continued.*

CRUISE VI, PACIFIC OCEAN, 1920–1921—*Continued.*

Station	Lat.	Long. East of Gr.	Date	Declination L. M. T.		Declination Value	Declination Wt.	Inclination L. M. T.		Inclination Value	Inclination Wt.	Hor. intensity L. M. T.		Hor. intensity Value	Hor. intensity Wt.	Instruments Compass	Instruments Dip Circle	Remarks Course	Remarks Roll	Remarks Sea	Weather
	° ′	° ′	1921	h	h	° ′		h	h	° ′		h	h	c. g. s.				°	°		
836CVI	39 02 N	218 45	Feb 9	....	....	....	..	14.9	....	59 37 N	2	14.9	....	0.2478	2	D5	189.1,2,11,12†	84	20	R	or
837CVI	38 39 N	221 58	Feb 10	....	....	....	..	14.7	....	59 44 N	1	14.7	....	.2490	1	D5	189.1,2,11,12†	84	17	R	om
838CVI	38 22 N	224 10	Feb 11	....	....	....	..	15.6	....	60 26 N	2	15.6	....	.2479	2	D5	EI3,189.1,2,11,12†	79	8	M	or
839CVI[1]	37 57 N	225 24	Feb 12	....	....	....	..	14.7	....	59 38 N	1	14.7	....	.2529	1	D5	189.1,2,11,12†	79	32	H	oqr
840CVI[1]	37 52 N	225 35	Do.	19.2	....	18 08 E	1	....	....	....	..	....	....	......	..	C1	....	56	25	H	cq
841CVI[1]	37 43 N	226 08	Feb 13	8.1	....	18 16 E	2	....	....	....	..	....	....	......	..	C1, D5	....	45	24	HR	bcq
842CVI[1]	37 40 N	226 29	Do.	16.3	....	18 11 E	1	....	....	....	..	....	....	......	..	C1, D5	....	56	27	HR	bcq
843CVI	37 30 N	226 50	Feb 14	7.8	....	18 38 E	2	....	....	....	..	....	....	......	..	C1, D5	....	68	22	R	cq
844CVI	37 29 N	226 55	Do.	8.8	....	17 58 E	2	....	....	....	..	....	....	......	..	D5	....	68	22	R	cq
845CVI	37 32 N	227 16	Do.	....	....	....	..	15.2	....	59 46 N	2	15.2	....	.2531	2	D5	EI3,189.1,2,11,12†	56	17	M	bc
846CVI	37 34 N	227 24	Do.	17.2	....	18 38 E	1	....	....	....	..	....	....	......	..	C1	....	39	17	L	c
847CVI	37 45 N	229 23	Feb 15	7.4	....	18 35 E	3	....	....	....	..	....	....	......	..	C1, D5	....	45	11	M	cqr
848CVI	38 08 N	230 28	Do.	....	....	....	..	14.6	....	60 38 N	2	14.6	....	.2505	2	D5	189.1,2,11,12†	51	20	HR	or
849CVI[2]	38 44 N	230 53	Feb 16	9.3	....	19 16 E	1	....	....	....	..	....	....	......	..	C1	....	338	25	R	cq
850CVI[2]	38 50 N	230 49	Do.	....	....	....	..	14.9	....	61 40 N	1	14.9	....	.2450	1	D5	189.1,2,11,12†	124	25	R	oq
851CVI	38 40 N	230 50	Feb 17	8.1	....	18 35 E	3	....	....	....	..	....	....	......	..	C1, D5	....	112	10	L	bc
852CVI	38 34 N	231 11	Do.	....	....	....	..	14.6	....	61 10 N	3	14.6	....	.2503	3	D5	189.1,2,11,12†	84	13	LS	bc
853CVI	38 34 N	231 19	Do.	16.5	....	18 46 E	3	....	....	....	..	....	....	......	..	C1, D5	....	84	14	SL	bc
854CVI	38 21 N	233 19	Feb 18	10.8	....	18 43 E	1	....	....	....	..	....	....	......	..	C1, D5	....	84	8	S	c
855CVI	38 14 N	234 00	Do.	....	....	....	..	14.7	....	61 44 N	3	14.7	....	.2482	3	D5	EI3,189.1,2,11,12†	90	9	S	c
856CVI	38 12 N	234 12	Do.	15.9	....	18 29 E	3	....	....	....	..	....	....	......	..	C1, D5	....	90	9	MS	c
857CVI[2]	37 57 N	236 04	Feb 19	8.5	....	18 16 E	3	....	....	....	..	....	....	......	..	C1, D5	....	82, 68	7	S	c
858CVI	36 29 N	235 48	Mar 29	8.2	....	17 35 E	2	....	....	....	..	....	....	......	..	C1	....	225	7	M	c
859CVI	35 52 N	235 12	Do.	....	....	....	..	14.8	....	59 51 N	3	14.8	....	.2592	3	D5	EI3,189.1,2,11,12†	208	10	M	c
860CVI	35 46 N	235 08	Do.	15.6	....	17 12 E	2	....	....	....	..	....	....	......	..	C1	....	197	10	M	c
861CVI	35 40 N	235 02	Do.	16.5	....	17 12 E	2	....	....	....	..	....	....	......	..	D5	....	202	10	M	c
862CVI	34 04 N	233 25	Mar 30	7.1	....	16 36 E	3	....	....	....	..	....	....	......	..	C1, D5	....	208	10	M	c
863CVI	33 19 N	232 33	Do.	....	....	....	..	15.1	....	57 07 N	3	15.1	....	.2686	3	D5	EI3,189.1,2,11,12†	214	14	M	c
864CVI	33 09 N	232 21	Do.	17.0	....	16 20 E	3	....	....	....	..	....	....	......	..	C1, D5	....	202	13	M	bc
865CVI	32 16 N	231 12	Mar 31	6.8	....	16 04 E	3	....	....	....	..	....	....	......	..	C1, D5	....	214	11	MS	c
866CVI	31 46 N	230 33	Do.	....	....	....	..	14.9	....	54 52 N	3	14.8	....	.2770	3	D5	EI3,189.1,2,11,12†	214	14	M	c
867CVI	31 37 N	230 21	Do.	17.1	....	16 05 E	3	....	....	....	..	....	....	......	..	C1, D5	....	208	13	M	c
868CVI	30 20 N	228 41	Apr 1	....	....	....	..	15.1	....	52 56 N	3	15.0	....	.2806	3	D5	EI7,189.1,2,11,12†	214	13	S	c
869CVI	29 17 N	227 26	Apr 2	8.6	....	14 53 E	2	....	....	....	..	....	....	......	..	C1	....	214	14	S	c
870CVI	28 52 N	226 57	Do.	....	....	....	..	14.7	....	51 16 N	3	14.7	....	.2846	3	D5	EI3,189.1,2,11,12†	214	5	S	c
871CVI	28 43 N	226 47	Do.	16.5	....	14 28 E	3	....	....	....	..	....	....	......	..	C1, D5	....	202	12	S	c
872CVI	27 32 N	225 19	Apr 3	7.3	....	14 00 E	3	....	....	....	..	....	....	......	..	C1, D5	....	214	16	M	c
873CVI	26 57 N	224 18	Do.	....	....	....	..	15.4	....	48 20 N	2	15.3	....	.2898	2	D5	EI7,189.1,2,11,12†	242	21	M	c
874CVI	26 51 N	224 00	Do.	17.4	....	13 17 E	3	....	....	....	..	....	....	......	..	C1, D5	....	180	20	M	cr
875CVI	26 20 N	221 55	Apr 4	7.3	....	13 36 E	2	....	....	....	..	....	....	......	..	C1	....	298	18	R	c
876CVI	26 05 N	220 51	Do.	....	....	....	..	14.7	....	47 10 N	2	14.7	....	.2895	2	D5	EI3,189.1,2,11,12†	242	24	R	c
877CVI	26 00 N	220 29	Do.	17.4	....	13 02 E	2	....	....	....	..	....	....	......	..	C1, D5	....	191	19	R	c
878CVI	25 39 N	218 44	Apr 5	8.0	....	13 14 E	3	....	....	....	..	....	....	......	..	C1, D5	....	242	17	M	bcoqr
879CVI	25 32 N	218 03	Do.	....	....	....	..	14.9	....	46 01 N	3	14.9	....	.2896	3	D5	EI7,189.1,2,11,12†	242	16	M	bc
880CVI	25 30 N	217 52	Do.	16.9	....	12 52 E	2	....	....	....	..	....	....	......	..	C1, D5	....	242	16	M	bc
881CVI	25 18 N	216 31	Apr 6	6.2	....	12 47 E	3	....	....	....	..	....	....	......	..	C1, D5	....	242	7	M	bc
882CVI	25 14 N	215 57	Do.	....	....	....	..	14.5	....	45 11 N	2	14.5	....	.2884	3	D5	EI3,189.1,2,11,12†	236	12	M	bc
883CVI	25 13 N	215 49	Do.	17.1	....	12 39 E	3	....	....	....	..	....	....	......	..	C1, D5	....	236	11	SL	c

[1] Hove to in a gale.

[2] From February 20 to March 28 the *Carnegie* was at San Francisco.

CRUISE VI, PACIFIC OCEAN, 1920–1921—*Continued.*

	° ′	° ′	*1921*	h	h	° ′		h	h	° ′		h	h	c.g.s.				°	°		
884CVI	25 09 N	214 59	Apr 7	7.5	....	12 17 E	3	....	....	....	..	....	....	......	..	C1, D5	....	284	18	SL	bc
885CVI	24 56 N	214 20	Do.	....	....	....	..	15.0	....	44 30 N	2	15.0	....	0.2900	2	D5	EI7,189.1,2,*11,12*†	236	15	L	o
886CVI	24 49 N	214 04	Do.	17.2	....	12 26 E	3	....	....	....	..	....	....	......	..	C1, D5	....	231	23	M	bc
887CVI	23 53 N	212 17	Apr 8	8.4	....	12 03 E	1	....	....	....	..	....	....	......	..	C1	....	231	19	M	c
888CVI	23 36 N	211 35	Do.	....	....	....	..	14.7	....	42 40 N	2	14.7	....	.2913	2	D5	EI3,189.1,2,*11,12*†	242	18	M	bc
889CVI	23 31 N	211 17	Do.	17.2	....	11 43 E	3	....	....	....	..	....	....	......	..	C1, D5	....	242	16	M	bc
890CVI	23 07 N	209 50	Apr 9	8.1	....	11 30 E	1	....	....	....	..	....	....	......	..	C1	....	242	14	M	c
891CVI	22 56 N	209 13	Do.	....	....	....	..	15.0	....	41 41 N	3	15.0	....	.2898	3	D5	EI7,189.1,2,*11,12*†	242	16	L	o
892CVI	22 52 N	209 02	Do.	16.9	....	11 37 E	3	....	....	....	..	....	....	......	..	C1, D5	....	202	12	ML	bc
893CVI	22 22 N	207 29	Apr 10	8.3	....	11 25 E	1	....	....	....	..	....	....	......	..	C1	....	242	10	M	c
894CVI	22 12 N	206 48	Do.	....	....	....	..	14.8	....	40 28 N	3	14.8	....	.2905	3	D5	EI3,189.1,2,*11,12*†	248	14	MS	bc
895CVI	22 09 N	206 32	Do.	17.1	....	11 19 E	3	....	....	....	..	....	....	......	..	C1, D5	....	248	15	S	bc
896CVI	21 52 N	204 52	Apr 11	7.4	....	11 05 E	3	....	....	....	..	....	....	......	..	C1, D5	....	248	14	M	c
897CVI	21 40 N	203 58	Do.	....	....	....	..	14.8	....	39 01 N	3	14.8	....	.2934	3	D5	EI7,189.1,2,*11,12*†	242	12	M	bc
898CVI[1]	21 34 N	203 37	Do.	17.2	....	10 45 E	3	....	....	....	..	....	....	......	..	C1, D5	....	242	12	M	bc
899CVI	22 28 N	200 52	Apr 29	6.0	....	11 00 E	3	....	....	....	..	....	....	......	..	C1, D5	....	315	14	M	bc
900CVI	23 16 N	200 12	Do.	....	....	....	..	14.7	....	40 38 N	3	14.7	....	.2856	3	D5	EI3,189.1,2,*11,12*†	315	11	M	bc
901CVI	23 30 N	200 01	Do.	17.5	....	11 11 E	3	....	....	....	..	....	....	......	..	C1, D5	....	315	14	M	bc
902CVI	24 33 N	199 08	Apr 30	6.5	....	11 24 E	3	....	....	....	..	....	....	......	..	C1, D5	....	315	18	M	bc
903CVI	25 18 N	198 34	Do.	....	....	....	..	14.7	....	42 53 N	2	14.7	....	.2801	2	D5	EI3,189.1,2,*11,12*†	315	16	M	bc
904CVI	25 32 N	198 28	Do.	17.4	....	11 42 E	3	....	....	....	..	....	....	......	..	C1, D5	....	338	14	M	bc
905CVI	26 51 N	198 09	May 1	6.7	....	12 02 E	2	....	....	....	..	....	....	......	..	C1, D5	....	338	14	M	o
906CVI	27 33 N	198 01	Do.	....	....	....	..	15.0	....	45 21 N	3	14.9	....	.2755	3	D5	EI7,189.1,2,*11,12*†	338	17	M	o
907CVI	27 46 N	197 57	Do.	17.3	....	11 54 E	3	....	....	....	..	....	....	......	..	C1, D5	....	338	16	M	bc
908CVI	29 04 N	197 31	May 2	7.7	....	12 38 E	2	....	....	....	..	....	....	......	..	C1	....	338	19	M	c
909CVI	29 52 N	197 22	Do.	....	....	....	..	14.6	....	47 32 N	2	14.6	....	.2695	2	D5	EI3,189.1,2,*11,12*†	338	16	M	c
910CVI	30 09 N	197 20	Do.	17.0	....	12 46 E	2	....	....	....	..	....	....	......	..	C1	....	343	16	M	oz
911CVI	32 00 N	197 03	May 3	9.6	....	13 24 E	1	....	....	....	..	....	....	......	..	C1	....	34	12	M	cr
912CVI	32 28 N	197 39	Do.	....	....	....	..	15.4	....	50 04 N	2	15.4	....	.2612	2	D5	EI7,189.1,2,*11,12*†	45	12	M	or
913CVI	33 40 N	199 16	May 4	8.5	....	13 39 E	1	....	....	....	..	....	....	......	..	C1	....	45	18	R	cqd
914CVI	33 53 N	199 50	Do.	....	....	....	..	14.8	....	52 03 N	2	14.8	....	.2594	2	D5	EI3,189.1,2,*11,12*†	68	15	R	bc
915CVI	33 54 N	199 56	Do.	16.6	....	14 12 E	2	....	....	....	..	....	....	......	..	C1, D5	....	68	17	RC	bc
916CVI	33 57 N	200 08	May 5	7.5	....	14 06 E	2	....	....	....	..	....	....	......	..	C1, D5	....	56	24	ML	bc
917CVI	34 02 N	200 56	Do.	17.2	....	14 07 E	3	....	....	....	..	....	....	......	..	C1, D5	....	68	10	MS	bc
918CVI	34 05 N	201 59	May 6	5.7	....	14 26 E	3	....	....	....	..	....	....	......	..	C1, D5	....	70	15	MS	bcq
919CVI	34 07 N	202 40	Do.	....	....	....	..	15.0	....	52 30 N	3	15.0	....	.2598	3	D5	EI7,189.1,2,*11,12*†	68	22	SL	bc
920CVI	34 08 N	202 49	Do.	16.9	....	14 24 E	3	....	....	....	..	....	....	......	..	C1, D5	....	68	19	SL	bc
921CVI	34 09 N	203 46	May 7	6.0	....	14 40 E	3	....	....	....	..	....	....	......	..	C1, D5	....	70	12	S	bc
922CVI	34 10 N	204 25	Do.	....	....	....	..	14.7	....	53 04 N	3	14.7	....	.2600	3	D5	EI3,189.1,2,*11,12*†	68	14	S	bc
923CVI	34 11 N	204 39	Do.	17.5	....	14 40 E	3	....	....	....	..	....	....	......	..	C1, D5	....	68	18	MS	bc
924CVI	34 12 N	205 18	May 8	6.0	....	14 56 E	3	....	....	....	..	....	....	......	..	C1, D5	....	73	15	MS	bc
925CVI	34 05 N	205 53	Do.	....	....	....	..	14.5	....	53 08 N	3	14.5	....	.2606	3	D5	189.1,2,*11,12*†	101	9	S	bcq
926CVI	34 02 N	206 07	Do.	17.7	....	14 51 E	3	....	....	....	..	....	....	......	..	C1, D5	....	68	14	MS	bc
927CVI	33 51 N	206 55	May 9	5.6	....	14 54 E	3	....	....	....	..	....	....	......	..	C1, D5	....	82	10	MS	bc
928CVI	33 37 N	207 29	Do.	....	....	....	..	14.6	....	53 01 N	3	14.6	....	.2619	3	D5	EI3,189.1,2,*11,12*†	90	7	S	bc
929CVI	33 31 N	207 48	Do.	17.5	....	14 57 E	3	....	....	....	..	....	....	......	..	C1, D5	....	118	8	MS	bc
930CVI	33 26 N	209 08	May 10	6.4	....	15 18 E	3	....	....	....	..	....	....	......	..	C1, D5	....	79	11	M	bc
931CVI	33 41 N	210 14	Do.	....	....	....	..	14.8	....	52 52 N	2	14.8	....	.2652	2	D5	EI7,189.1,2,*11,12*†	56	15	R	cqd
932CVI	33 45 N	210 34	Do.	16.9	....	15 11 E	2	....	....	....	..	....	....	......	..	C1	....	56	16	R	c
933CVI	34 08 N	212 34	May 11	7.9	....	15 40 E	1	....	....	....	..	....	....	......	..	C1	....	101	19	R	c
934CVI	34 09 N	213 24	Do.	....	....	....	..	14.8	....	54 26 N	2	14.8	....	.2621	2	D5	EI3,189,1,2,*11,12*†	73	20	M	bc
935CVI	34 10 N	213 43	Do.	17.7	....	15 44 E	3	....	....	....	..	....	....	......	..	C1, D5	....	73	18	M	bc
936CVI	34 15 N	215 21	May 12	6.4	....	15 56 E	3	....	....	....	..	....	....	......	..	C1, D5	....	76	12	M	bcq
937CVI	34 12 N	216 04	Do.	....	....	....	..	14.7	....	54 46 N	2	14.7	....	.2628	2	D5	EI7,189.1,2,*11,12*†	101	18	M	bc
938CVI	34 07 N	216 14	Do.	18.7	....	16 02 E	2	....	....	....	..	....	....	......	..	C1, D5	....	107	17	M	c
939CVI	33 50 N	216 56	May 13	7.8	....	16 12 E	1	....	....	....	..	....	....	......	..	C1, D5	....	158	10	S	c
940CVI	33 42 N	217 18	Do.	....	....	....	..	14.6	....	54 40 N	3	14.6	....	.2629	3	D5	EI3,189.1,2,*11,12*†	101	12	S	c
941CVI	33 39 N	217 23	Do.	17.7	....	15 58 E	3	....	....	....	..	....	....	......	..	C1, D5	....	101	11	MS	bc

[1] From April 12 to April 28 the *Carnegie* was at Honolulu.

FINAL RESULTS OF OCEAN MAGNETIC OBSERVATIONS ON THE CARNEGIE, 1915–1921—*Continued.*

CRUISE VI, PACIFIC OCEAN, 1920–1921—*Continued.*

Station	Lat.	Long. East of Gr.	Date	Declination L. M. T.		Declination Value	Declination Wt.	Inclination L. M. T.		Inclination Value	Inclination Wt.	Hor. intensity L. M. T.		Hor. intensity Value	Hor. intensity Wt.	Instruments Compass	Instruments Dip Circle	Remarks Course	Remarks Roll	Remarks Sea	Remarks Weather
	° ′	° ′	*1921*	h	h	° ′		h	h	° ′		h	h	c. g. s.				°	°		
942CVI	33 16 N	218 12	May 14	5.5	....	15 55 E	3	....	....	....	..	....	....	......	..	C1, D5	....	101	7	S	bo
943CVI	32 39 N	218 59	Do.	....	....	....	..	14.9	....	53 58 N	3	15.0	....	0.2667	3	D5	EI7,189.1,2,*11*,*12*†	124	7	S	bc
944CVI	32 29 N	219 07	Do.	17.0	....	15 27 E	2	....	....	....	..	....	....	......	..	C1	....	124	7	S	o
945CVI	31 12 N	219 49	May 15	6.1	....	15 14 E	3	....	....	....	..	....	....	......	..	C1, D5	....	112	5	S	bc
946CVI	30 20 N	220 26	Do.	....	....	....	..	14.8	....	52 16 N	3	14.8	....	.2734	3	D5	EI3,189.1,2,*11*,*12*†	129	7	S	bc
947CVI	30 02 N	220 38	Do.	17.6	....	14 12 E	3	....	....	....	..	....	....	......	..	C1, D5	....	135	6	S	bc
948CVI	28 54 N	221 22	May 16	7.1	....	14 17 E	2	....	....	....	..	....	....	......	..	C1	....	129	9	M	o
949CVI	28 12 N	221 47	Do.	....	....	....	..	15.1	....	50 01 N	3	15.2	....	.2822	3	D5	EI7,189.1,2,*11*,*12*†	129	10	M	bc
950CVI	27 59 N	221 55	Do.	17.2	....	13 58 E	1	....	....	....	..	....	....	......	..	C1	....	129	6	M	o
951CVI	26 06 N	222 38	May 17	....	....	....	..	14.8	....	47 37 N	3	14.9	....	.2894	3	D5	EI3,189.1,2,*11*,*12*†	129	9	M	o
952CVI	25 52 N	222 47	Do.	17.5	....	13 16 E	3	....	....	....	..	....	....	......	..	C1, D5	....	129	10	M	bc
953CVI	24 46 N	223 23	May 18	7.2	....	12 59 E	3	....	....	....	..	....	....	......	..	C1, D5	....	135	10	M	oq
954CVI	24 00 N	223 49	Do.	....	....	....	..	15.5	....	45 13 N	2	15.5	....	.2958	2	D5	EI7,189.1,2,*11*,*12*†	135	11	M	o
955CVI	23 48 N	223 55	Do.	17.5	....	12 26 E	3	....	....	....	..	....	....	......	..	C1, D5	....	135	10	M	bc
956CVI	22 12 N	224 32	May 19	9.5	....	12 19 E	1	....	....	....	..	....	....	......	..	C1	....	132	10	M	o
957CVI	21 43 N	224 44	Do.	....	....	....	..	14.8	....	42 38 N	2	14.8	....	.3024	2	D5	EI3,189.1,2,*11*,*12*†	141	15	M	o
958CVI	21 35 N	224 51	Do.	16.8	....	11 53 E	3	....	....	....	..	....	....	......	..	C1, D5	....	141	12	M	bc
959CVI	20 33 N	225 33	May 20	6.0	....	11 32 E	3	....	....	....	..	....	....	......	..	C1, D5	....	135	6	M	od
960CVI	19 58 N	225 47	Do.	....	....	....	..	14.6	....	40 02 N	3	14.6	....	.3092	3	D5	EI7,189.1,2,*11*,*12*†	135	11	M	bc
961CVI	19 46 N	225 52	Do.	16.9	....	11 11 E	3	....	....	....	..	....	....	......	..	C1, D5	....	135	7	M	bc
962CVI	18 28 N	226 23	May 21	7.6	....	10 59 E	2	....	....	....	..	....	....	......	..	C1	....	135	6	M	o
963CVI	17 55 N	226 40	Do.	....	....	....	..	14.8	....	37 21 N	3	14.8	....	.3149	3	D5	EI3,189.1,2,*11*,*12*†	135	8	M	o
964CVI	17 44 N	226 44	Do.	16.9	....	10 37 E	2	....	....	....	..	....	....	......	..	C1	....	146	9	S	o
965CVI	16 43 N	226 03	May 22	7.6	....	10 25 E	2	....	....	....	..	....	....	......	..	C1	....	231	10	S	o
966CVI	16 08 N	225 40	Do.	....	....	....	..	15.3	....	34 20 N	3	15.3	....	.3186	3	D5	EI7,189.1,2,*11*,*12*†	197	10	S	bc
967CVI	15 56 N	225 32	Do.	17.7	....	10 02 E	3	....	....	....	..	....	....	......	..	C1, D5	....	197	11	S	bc
968CVI	14 58 N	224 53	May 23	6.3	....	9 59 E	3	....	....	....	..	....	....	......	..	C1, D5	....	197	10	MS	bc
969CVI	14 12 N	224 23	Do.	....	....	....	..	14.8	....	31 28 N	3	14.8	....	.3218	3	D5	EI3,189.1,2,*11*,*12*†	202	20	M	bc
970CVI	13 56 N	224 12	Do.	17.4	....	9 47 E	3	....	....	....	..	....	....	......	..	C1, D5	....	202	14	M	bc
971CVI	12 38 N	223 09	May 24	8.2	....	9 30 E	1	....	....	....	..	....	....	......	..	C1	....	202	12	M	o
972CVI	12 11 N	222 44	Do.	....	....	....	..	15.0	....	27 37 N	3	15.0	....	.3254	3	D5	EI7,189.1,2,*11*,*12*†	214	10	M	o
973CVI	10 52 N	221 22	May 25	6.9	....	9 08 E	3	....	....	....	..	....	....	......	..	C1, D5	....	214	13	M	o
974CVI	10 21 N	220 46	Do.	....	....	....	..	14.8	....	24 07 N	2	14.8	....	.3282	3	D5	EI3,189.1,2,*11*,*12*†	214	8	M	or
975CVI	10 16 N	220 38	Do.	16.7	....	9 04 E	3	....	....	....	..	....	....	......	..	C1, D5	....	214	10	M	o
976CVI	9 25 N	219 43	May 26	7.0	....	8 59 E	3	....	....	....	..	....	....	......	..	C1, D5	....	214	13	M	bc
977CVI	8 51 N	219 03	Do.	....	....	....	..	14.8	....	21 00 N	3	14.8	....	.3313	3	D5	EI7,189.1,2,*11*,*12*†	214	16	M	bc
978CVI	8 40 N	218 52	Do.	17.0	....	8 35 E	3	....	....	....	..	....	....	......	..	C1, D5	....	208	11	M	bcqd
979CVI	8 03 N	218 08	May 27	7.3	....	8 46 E	3	....	....	....	..	....	....	......	..	C1, D5	....	208	9	S	o
980CVI	7 46 N	217 52	Do.	....	....	....	..	14.4	....	18 57 N	3	14.4	....	.3313	3	D5	189.1,2,*11*,*12*†	202	10	S	o
981CVI	7 39 N	217 47	Do.	16.4	....	8 40 E	2	....	....	....	..	....	....	......	..	C1	....	202	8	S	o
982CVI	7 07 N	217 35	May 28	7.2	....	8 22 E	3	....	....	....	..	....	....	......	..	C1, D5	....	202	10	S	o
983CVI	6 44 N	217 28	Do.	....	....	....	..	15.4	....	16 55 N	3	15.4	....	.3337	3	D5	189.1,2,*11*,*12*†	202	12	SL	bcqr
984CVI	6 39 N	217 26	Do.	17.3	....	8 35 E	3	....	....	....	..	....	....	......	..	C1, D5	....	202	12	S	o
985CVI	5 53 N	217 14	May 29	9.2	....	8 41 E	1	....	....	....	..	....	....	......	..	C1	....	202	10	S	o
986CVI	5 46 N	217 06	Do.	....	....	....	..	14.7	....	15 02 N	3	14.7	....	.3351	3	D5	EI3,189.1,2,*11*,*12*†	219	12	S	od
987CVI	5 47 N	217 05	Do.	16.3	....	8 30 E	2	....	....	....	..	....	....	......	..	C1	....	214	12	S	o
988CVI	5 02 N	216 13	May 30	....	....	....	..	15.4	....	13 41 N	3	15.4	....	.3368	3	D5	189.1,2,*11*,*12*†	214	14	SL	or
989CVI	4 40 N	215 33	May 31	6.8	....	8 20 E	3	....	....	....	..	....	....	......	..	C1, D5	....	214	7	S	bc
990CVI	4 29 N	215 20	Do.	....	....	....	..	14.7	....	12 25 N	3	14.7	....	.3362	3	D5	EI7,189.1,2,*11*,*12*†	214	12	S	bc

CRUISE VI, PACIFIC OCEAN, 1920–1921—*Continued.*

	° ′	° ′	*1921*	h	h	° ′		h	h	° ′		h	h	c. g. s.				°	°		
991CVI[1]	4 26 N	215 17	May 31	16.3,	17.8	8 23 E	3	....	....	....	..	....	....	......	..	C1, D5	....	Swing	10	S	bc
992CVI	4 07 N	214 52	Jun 1	7.4	....	8 10 E	3	....	....	....	..	....	....	......	..	C1, D5	....	214	10	S	o
993CVI	3 58 N	214 33	Do.	....	....	....	..	14.8	....	11 07 N	3	14.8	....	0.3390	3	D5	EI3,189.1,2,*11,12*†	214	12	S	bc
994CVI	3 46 N	214 23	Do.	17.5	....	8 11 E	3	....	....	....	..	....	....	......	..	C1, D5	....	214	6	S	bc
995CVI	3 03 N	213 32	Jun 2	6.2	....	8 22 E	3	....	....	....	..	....	....	......	..	C1, D5	....	222	4	S	bc
996CVI	2 26 N	212 50	Do.	....	....	....	..	14.8	....	7 49 N	3	14.9	....	.3401	3	D5	EI7,189.1,2,*11,12*†	208	10	S	bc
997CVI	2 14 N	212 41	Do.	17.2	....	8 15 E	3	....	....	....	..	....	....	......	..	C1, D5	....	208	10	M	bc
998CVI	1 00 N	211 49	Jun 3	6.4	....	8 01 E	3	....	....	....	..	....	....	......	..	C1, D5	....	202	8	M	bc
999CVI	0 16 N	211 22	Do.	....	....	....	..	14.8	....	3 08 N	3	14.8	....	.3430	3	D5	EI3,189.1,2,*11,12*†	214	17	M	bc
1000CVI	0 09 N	211 16	Do.	16.9	....	8 03 E	3	....	....	....	..	....	....	......	..	C1, D5	....	214	10	M	bc
1001CVI	0 31 S	210 39	Jun 4	6.7	....	8 13 E	3	....	....	....	..	....	....	......	..	C1, D5	....	214	10	S	bc
1002CVI	0 51 S	210 23	Do.	....	....	....	..	15.0	....	0 58 N	3	15.0	....	.3431	3	D5	EI7,189.1,2,*11,12*†	214	10	S	bc
1003CVI	0 56 S	210 19	Do.	17.2	....	8 19 E	3	....	....	....	..	....	....	......	..	C1, D5	....	214	8	S	bc
1004CVI	1 31 S	209 47	Jun 5	6.7	....	8 11 E	3	....	....	....	..	....	....	......	..	C1, D5	....	214	9	S	bc
1005CVI	1 50 S	209 31	Do.	....	....	....	..	14.7	....	0 54 S	3	14.7	....	.3446	3	D5	EI3,189.1,2,*11,12*†	214	10	S	bc
1006CVI	1 55 S	209 27	Do.	16.8	....	8 25 E	3	....	....	....	..	....	....	......	..	C1, D5	....	214	10	S	bc
1007CVI	2 42 S	208 32	Jun 6	6.7	....	8 19 E	3	....	....	....	..	....	....	......	..	C1, D5	....	214	6	S	bc
1008CVI	3 06 S	208 01	Do.	....	....	....	..	14.7	....	4 11 S	3	14.7	....	.3458	3	D5	EI7,189.1,2,*11,12*†	208	7	S	bc
1009CVI	3 12 S	207 54	Do.	17.1	....	8 10 E	3	....	....	....	..	....	....	......	..	C1, D5	....	208	7	S	bc
1010CVI	3 36 S	207 21	Jun 7	6.7	....	8 24 E	3	....	....	....	..	....	....	......	..	C1, D5	....	208	5	S	bc
1011CVI	4 46 S	206 10	Jun 8	6.8	....	8 31 E	3	....	....	....	..	....	....	......	..	C1, D5	....	202	8	S	bc
1012CVI	5 22 S	205 39	Do.	....	....	....	..	14.8	....	9 22 S	3	14.8	....	.3492	3	D5	EI3,189.1,2,*11,12*†	202	11	M	bc
1013CVI	5 29 S	205 31	Do.	16.9	....	8 22 E	3	....	....	....	..	....	....	......	..	C1, D5	....	202	10	M	bc
1014CVI	6 24 S	204 46	Jun 9	6.7	....	8 38 E	3	....	....	....	..	....	....	......	..	C1, D5	....	202	9	MS	bc
1015CVI	6 49 S	204 25	Do.	....	....	....	..	14.9	....	12 24 S	3	14.9	....	.3465	3	D5	EI7,189.1,2,*11,12*†	202	8	S	bc
1016CVI	6 55 S	204 20	Do.	17.1	....	8 30 E	3	....	....	....	..	....	....	......	..	C1, D5	....	202	8	S	bc
1017CVI	7 32 S	203 51	Jun 10	6.8	....	8 43 E	3	....	....	....	..	....	....	......	..	C1, D5	....	202	8	S	bc
1018CVI	7 56 S	203 28	Do.	....	....	....	..	14.8	....	14 52 S	2	14.8	....	.3504	2	D5	EI3,189.1,2,*11,12*†	214	14	L	bc
1019CVI	8 02 S	203 22	Do.	16.8	....	8 35 E	3	....	....	....	..	....	....	......	..	C1, D5	....	214	12	L	bcq
1020CVI	8 46 S	202 38	Jun 11	....	....	....	..	14.5	....	16 25 S	3	14.5	....	.3502	3	D5	189.1,2,*11,12*†	248	12	L	bc
1021CVI	8 48 S	202 30	Do.	16.8	....	8 55 E	3	....	....	....	..	....	....	......	..	C1, D5	....	248	12	L	bc
1022CVI[2]	8 49 S	202 03	Jun 12	6.7	....	8 58 E	3	....	....	....	..	....	....	......	..	C1, D5	....	219	9	L	bc
1023CVI	9 18 S	201 21	Jun 13	6.9	....	8 59 E	3	....	....	....	..	....	....	......	..	C1,D5	....	225	10	L	bc
1024CVI	9 35 S	200 56	Do.	....	....	....	..	14.9	....	18 34 S	3	14.8	....	.3506	3	D5	EI7,189.1,2,*11,12*†	225	10	L	bc
1025CVI	10 06 S	200 21	Jun 14	6.8	....	8 53 E	3	....	....	....	..	....	....	......	..	C1, D5	....	225	10	L	bc
1026CVI	10 13 S	199 52	Do.	....	....	....	..	14.7	....	19 25 S	2	14.7	....	.3496	2	D5	EI3,189.1,2,*11,12*†	253	16	L	bc
1027CVI	10 14 S	199 40	Do.	16.9	....	9 33 E	3	....	....	....	..	....	....	......	..	C1, D5	....	253	18	L	bc
1028CVI[3]	10 08 S	199 00	Jun 15	7.3	....	8 27 E	3	....	....	....	..	....	....	......	..	C1, D5	....	191	8	L	bcq
1029CVI[4]	10 26 S	198 51	Do.	16.9	....	9 23 E	3	....	....	....	..	....	....	......	..	C1, D5	....	236	15	L	o
1030CVI	10 55 S	197 47	Jun 16	6.8	....	9 19 E	3	....	....	....	..	....	....	......	..	C1, D5	....	236	12	L	bc
1031CVI	11 10 S	197 07	Do.	....	....	....	..	15.0	....	22 30 S	2	15.0	....	.3514	2	D5	EI7,189.1,2,*11,12*†	236	22	L	o
1032CVI	11 14 S	196 56	Do.	16.8	....	9 02 E	2	....	....	....	..	....	....	......	..	C1	....	236	20	L	o
1033CVI	11 29 S	196 13	Jun 17	7.8	....	9 18 E	2	....	....	....	..	....	....	......	..	C1, D5	....	236	15	L	bc
1034CVI	11 47 S	195 36	Do.	....	....	....	..	14.7	....	23 37 S	3	14.7	....	.3508	3	D5	EI3,189.1,2,*11,12*†	231	12	L	o
1035CVI	11 50 S	195 28	Do.	16.6	....	9 26 E	3	....	....	....	..	....	....	......	..	C1, D5	....	231	13	L	bc
1036CVI	12 06 S	194 44	Jun 18	6.8	....	9 35 E	3	....	....	....	..	....	....	......	..	C1, D5	....	225	7	L	bc
1037CVI	12 20 S	194 13	Do.	....	....	....	..	14.8	....	25 02 S	3	14.8	....	.3514	3	D5	EI7,189.1,2,*11,12*†	225	8	ML	bc
1038CVI	12 26 S	194 02	Do.	16.9	....	9 29 E	3	....	....	....	..	....	....	......	..	C1, D5	....	225	7	L	bc
1039CVI	13 11 S	192 38	Jun 19	6.9	....	9 47 E	3	....	....	....	..	....	....	......	..	C1, D5	....	225	8	L	bc
1040CVI	13 27 S	192 06	Do.	....	....	....	..	14.6	....	27 32 S	3	14.6	....	.3534	3	D5	EI3,189.1,2,*11,12*†	225	8	L	bc
1041CVI	13 33 S	191 54	Do.	16.7	....	9 42 E	3	....	....	....	..	....	....	......	..	C1, D5	....	225	10	L	bc
1042CVI[5]	14 05 S	190 30	Jun 20	7.1	....	10 50 E	3	....	....	....	..	....	....	......	..	C1, D5	....	262	7	L	bc
1043CVI	13 20 S	187 47	Jul 26	7.4	....	9 28 E	3	....	....	....	..	....	....	......	..	C1, D5	....	270	10	S	bc
1044CVI	13 23 S	187 18	Do.	17.6	....	9 53 E	3	....	....	....	..	....	....	......	..	C1, D5	....	236	5	S	bc
1045CVI	14 05 S	186 53	Jul 27	6.7	....	10 01 E	3	....	....	....	..	....	....	......	..	C1, D5	....	191	7	S	bc
1046CVI	14 32 S	187 09	Do.	....	....	....	..	14.4	....	30 16 S	3	14.4	....	.3524	3	D5	189.1,2,*11,12*†	135	5	S	oqr
1047CVI	14 58 S	188 07	Jul 28	8.1	....	10 10 E	3	....	....	....	..	....	....	......	..	C1, D5	....	56	7	S	bc

[1] Swinging ship at sea. [2] Off Penrhyn Island. [3] Possible local disturbance off Rakahanga Island. [4] Off Manihiki Island.
[5] Possible local disturbance off Manua Islands. From June 20 to July 25 the *Carnegie* was at Pago Pago and Apia, Samoa.

FINAL RESULTS OF OCEAN MAGNETIC OBSERVATIONS ON THE CARNEGIE, 1915–1921—*Continued.*

CRUISE VI, PACIFIC OCEAN, 1920–1921—*Continued.*

Station	Lat.	Long. East of Gr.	Date	Declination L. M. T.		Declination Value	Wt.	Inclination L. M. T.		Inclination Value	Wt.	Hor. intensity L. M. T.		Hor. intensity Value	Wt.	Instruments Compass	Instruments Dip Circle	Remarks Course	Roll	Sea	Weather
	° ′	° ′	1921	h	h	° ′		h	h	° ′		h	h	c. g. s.				°	°		
1048CVI	15 23 S	187 50	Jul 28	....	....	....	..	14.7	....	31 52 S	3	14.7	....	0.3489	3	D5	EI3,189.1,2,*11,12*†	180,191	8	S	bc
1049CVI	15 35 S	187 45	Do.	17.1	....	10 14 E	3	....	....	....	..	....	....	......	..	C1, D5	....	180	7	SL	bc
1050CVI	16 32 S	187 51	Jul 29	7.2	....	10 26 E	3	....	....	....	..	....	....	......	..	C1, D5	....	135	7	SL	bc
1051CVI	16 55 S	188 04	Do.	....	....	....	..	15.0	....	34 13 S	3	15.0	....	.3474	3	D5	EI7,189.1,2,*11,12*†	135	7	S	bc
1052CVI	16 59 S	188 06	Do.	17.3	....	10 29 E	3	....	....	....	..	....	....	......	..	C1, D5	....	124	6	SL	bc
1053CVI	17 49 S	188 39	Jul 30	17.3	....	10 34 E	2	....	....	....	..	....	....	......	..	C1	....	146	10	S	bc
1054CVI	18 12 S	188 38	Jul 31	7.3	....	10 49 E	3	....	....	....	..	....	....	......	..	C1, D5	....	180	7	S	bc
1055CVI	18 24 S	188 28	Do.	....	....	....	..	14.9	....	36 52 S	3	14.9	....	.3438	3	D5	EI3,189.1,2,*11,12*†	191	5	L	bc
1056CVI	19 01 S	187 58	Aug 1	7.2	....	10 41 E	3	....	....	....	..	....	....	......	..	C1, D5	....	163	4	L	bc
1057CVI	19 34 S	187 52	Do.	....	....	....	..	14.8	....	38 35 S	3	14.8	....	.3403	3	D5	EI7,189.1,2,*11,12*†	191	7	L	bc
1058CVI	19 47 S	187 47	Do.	16.7	....	10 47 E	3	....	....	....	..	....	....	......	..	C1, D5	....	186	7	L	bc
1059CVI	20 41 S	187 33	Aug 2	7.3	....	11 11 E	3	....	....	....	..	....	....	......	..	C1, D5	....	191	6	S	bc
1060CVI	21 02 S	187 30	Do.	....	....	....	..	14.9	....	40 43 S	3	14.9	....	.3366	3	D5	EI3,189 1,2,*11,12*†	169	9	S	bc
1061CVI	21 10 S	187 29	Do.	17.0	....	11 14 E	3	....	....	....	..	....	....	......	..	C1, D5	....	169	8	S	bc
1062CVI	22 00 S	187 31	Aug 3	....	....	....	..	14.7	....	42 29 S	3	14.7	....	.3324	3	D5	189 1,2,*11,12*†	169	10	S	bc
1063CVI	22 08 S	187 31	Do.	16.0	....	11 22 E	3	....	....	....	..	....	....	......	..	C1, D5	....	169	9	S	bc
1064CVI	23 10 S	187 35	Aug 4	7.4	....	11 44 E	3	....	....	....	..	....	....	......	..	C1, D5	....	169	8	SL	bcm
1065CVI	23 25 S	187 40	Do.	....	....	....	..	14.8	....	44 35 S	3	14.8	....	.3268	3	D5	EI7,189.1,2,*11,12*†	169	8	SL	bc
1066CVI	24 09 S	187 42	Aug 5	7.4	....	12 04 E	2	....	....	....	..	....	....	......	..	C1, D5	....	169	7	S	bc
1067CVI	24 21 S	188 11	Do.	....	....	....	..	15.0	....	45 42 S	3	15.0	....	.3244	3	D5	EI3,189.1,2,*11,12*†	45–112	3	S	bc
1068CVI	25 17 S	188 09	Aug 6	7.8	....	12 24 E	1	....	....	....	..	....	....	......	..	C1	....	169	7	SL	bc
1069CVI	25 27 S	188 15	Do.	....	....	....	..	15.0	....	47 10 S	3	15.0	....	.3202	3	D5	EI7,189.1,2,*11,12*†	169	7	SL	od
1070CVI	26 58 S	188 24	Aug 7	8.1	....	12 46 E	3	....	....	....	..	....	....	......	..	C1, D5	....	180	10	MC	bc
1071CVI	27 46 S	188 46	Do.	....	....	....	..	14.9	....	49 58 S	2	14.9	....	.3093	2	D5	EI3,189.1,2,*11,12*†	135	14	ML	bc
1072CVI	27 56 S	188 55	Do.	16.2	....	13 07 E	2	....	....	....	..	....	....	......	..	C1, D5	....	135	25	MR	bc
1073CVI	28 55 S	190 43	Aug 8	7.6	....	13 10 E	2	....	....	....	..	....	....	......	..	C1, D5	....	112	14	MR	bc
1074CVI	29 12 S	191 18	Do.	....	....	....	..	15.1	....	51 11 S	2	15.1	....	.3037	2	D5	EI7,189.1,2,*11,12*†	112	15	MR	om
1075CVI	29 58 S	192 18	Aug 9	8.3	....	13 32 E	2	....	....	....	..	....	....	......	..	C1	....	135	18	M	o
1076CVI	30 27 S	192 48	Do.	....	....	....	..	14.8	....	52 17 S	2	14.8	....	.3022	2	D5	EI3,189.1,2,*11,12*†	135	13	M	oq
1077CVI	30 35 S	192 56	Do.	16.3	....	13 51 E	2	....	....	....	..	....	....	......	..	C1	....	79	12	M	oq
1078CVI	29 42 S	194 16	Aug 10	8.2	....	13 25 E	3	....	....	....	..	....	....	......	..	C1, D5	....	6	12	M	bc
1079CVI	29 06 S	194 45	Do.	....	....	....	..	14.9	....	50 27 S	3	15.0	....	.3050	3	D5	EI7,189.1,2,*11,12*†	28	9	MR	bc
1080CVI	28 58 S	194 52	Do.	16.5	....	12 42 E	3	....	....	....	..	....	....	......	..	C1, D5	....	23	9	M	bc
1081CVI	27 31 S	195 58	Aug 11	7.8	....	12 25 E	2	....	....	....	..	....	....	......	..	C1	....	11	11	MS	o
1082CVI	26 45 S	196 29	Do.	....	....	....	..	14.9	....	46 59 S	2	14.9	....	.3148	2	D5	EI3,189.1,2,*11,12*†	34	8	M	o
1083CVI	25 23 S	197 25	Aug 12	9.2	....	12 11 E	2	....	....	....	..	....	....	......	..	C1, D5	....	11	8	M	bc
1084CVI	24 51 S	197 54	Do.	....	....	....	..	15.2	....	44 29 S	2	15.2	....	.3194	2	D5	EI7,189.1,2,*11,12*†	34	14	MR	oq
1085CVI	24 44 S	198 02	Do.	16.5	....	11 43 E	1	....	....	....	..	....	....	......	..	C1	....	39	14	MR	o
1086CVI	23 32 S	199 29	Aug 13	7.4	....	11 45 E	3	....	....	....	..	....	....	......	..	C1, D5	....	39	17	MR	bc
1087CVI[1]	22 44 S	199 54	Do.	....	....	....	..	14.6	....	41 17 S	2	14.6	....	.3260	2	D5	EI3,189.1,2,*11,12*†	6	8	MR	op
1088CVI	21 23 S	200 06	Aug 15	16.1	....	11 04 E	2	....	....	....	..	....	....	......	..	C1, D5	....	191	16	R	bq
1089CVI	22 48 S	199 54	Aug 16	8.0	....	11 34 E	2	....	....	....	..	....	....	......	..	C1	....	158	13	R	bc
1090CVI	23 18 S	200 00	Do.	16.6	....	12 26 E	3	....	....	....	..	....	....	......	..	C1, D5	....	169	14	M	bc
1091CVI	24 04 S	200 22	Aug 17	8.0	....	12 02 E	3	....	....	....	..	....	....	......	..	C1, D5	....	124	10	ML	bc
1092CVI	24 17 S	200 39	Do.	....	....	....	..	13.9	....	43 23 S	2	13.9	....	.3217	2	D5	189.2,*11,12*	112	8	MS	bc
1093CVI	24 26 S	202 26	Aug 18	7.6	....	12 15 E	2	....	....	....	..	....	....	......	..	C1, D5	....	101	8	S	bc
1094CVI	24 42 S	203 20	Do.	....	....	....	..	14.9	....	43 04 S	3	14.9	....	.3194	3	D5	EI3,189.1,2,*11,12*†	96	12	MS	bc
1095CVI	24 46 S	203 36	Do.	16.8	....	12 04 E	3	....	....	....	..	....	....	......	..	C1, D5	....	68	7	M	bc

[1] The *Carnegie* was at Rarotonga on August 14 and 15.

CRUISE VI, PACIFIC OCEAN, 1920–1921—*Continued.*

	° ′	° ′	*1921*	h	h	° ′		h	h	° ′		h	h	c.g.s.				°	°		
1096CVI	25 20 S	205 31	Aug 19	7.9	....	12 22 E	3	....	....	....	..	....	....	......	..	C1, D5	....	101	10	M	bc
1097CVI	25 34 S	206 30	Do.	....	....	....	..	15.2	....	43 43 S	1	15.2	....	0.3170	1	D5	E17,189.1,2,*11,12*†	96	16	R	bc
1098CVI	25 39 S	206 44	Do.	16.7	....	12 25 E	2	....	....	....	..	....	....	......	..	C1, D5	....	101	11	R	bcq
1099CVI	26 43 S	208 22	Aug 20	7.6	....	12 39 E	2	....	....	....	..	....	....	......	..	C1, D5	....	121	16	R	bcq
1100CVI	27 12 S	209 11	Do.	....	....	....	..	14.8	....	45 15 S	2	14.8	....	.3135	2	D5	E13,189.1,2,*11,12*†	112	10	RL	bc
1101CVI	27 18 S	209 25	Do.	16.6	....	13 07 E	3	....	....	....	..	....	....	......	..	C1, D5	....	112	17	RL	bc
1102CVI	27 54 S	211 21	Aug 21	7.3	....	13 11 E	2	....	....	....	..	....	....	......	..	C1, D5	....	112	18	RL	bcqr
1103CVI	28 17 S	212 13	Do.	....	....	....	..	14.5	....	45 57 S	1	14.5	....	.3088	1	D5	189.1,2,*11,12*†	101	20	HR	bcq
1104CVI	28 23 S	212 32	Do.	16.6	....	13 04 E	2	....	....	....	..	....	....	......	..	C1, D5	....	101	20	RL	bcq
1105CVI	28 55 S	214 19	Aug 22	7.4	....	13 28 E	2	....	....	....	..	....	....	......	..	C1, D5	....	101	17	RL	bcq
1106CVI	29 06 S	215 04	Do.	....	....	....	..	14.7	....	46 34 S	3	14.7	....	.3064	3	D5	E13,189.1,2,*11,12*†	101	15	R	bc
1107CVI	29 08 S	215 18	Do.	16.6	....	13 20 E	3	....	....	....	..	....	....	......	..	C1, D5	....	101	14	MR	bc
1108CVI	29 03 S	216 30	Aug 23	8.5	....	13 31 E	2	....	....	....	..	....	....	......	..	C1	....	11	8	ML	c
1109CVI	28 57 S	216 36	Do.	....	....	....	..	14.2	....	46 17 S	2	14.2	....	.3052	2	D5	189.1,2,*11,12*†	270	18	SL	c
1110CVI	29 07 S	216 34	Aug 24	16.9	....	13 17 E	3	....	....	....	..	....	....	......	..	C1, D5	....	124	8	S	bc
1111CVI	29 53 S	217 35	Aug 25	7.1	....	13 40 E	3	....	....	....	..	....	....	......	..	C1, D5	....	101	6	S	bc
1112CVI	29 57 S	217 44	Do.	8.3	....	13 37 E	3	....	....	....	..	....	....	......	..	C1, D5	....	101	6	S	bc
1113CVI	30 11 S	218 40	Do.	....	....	....	..	14.6	....	47 13 S	3	14.6	....	.3022	3	D5	E13,189.1,2,*11,12*†	79	10	MS	cdr
1114CVI	30 31 S	221 10	Aug 26	8.6	....	14 13 E	2	....	....	....	..	....	....	......	..	C1, D5	....	101	20	RL	cq
1115CVI	30 33 S	221 51	Do.	....	....	....	..	14.6	....	46 55 S	1	14.6	....	.3022	1	D5	189.1,2,*11,12*†	73	20	R	bc
1116CVI	30 05 S	223 59	Aug 27	8.2	....	13 29 E	3	....	....	....	..	....	....	......	..	C1, D5	....	11	14	R	bcq
1117CVI	29 44 S	224 46	Do.	....	....	....	..	14.2	....	45 17 S	2	14.2	....	.3029	2	D5	189.1,2,*11,12*†	56	17	R	bcq
1118CVI	29 37 S	225 01	Do.	16.1	....	13 27 E	2	....	....	....	..	....	....	......	..	C1, D5	....	56	10	R	bc
1119CVI	28 41 S	226 44	Aug 28	7.5	....	13 23 E	2	....	....	....	..	....	....	......	..	C1, D5	....	39	12	MR	bcq
1120CVI	28 13 S	227 27	Do.	....	....	....	..	14.4	....	43 32 S	3	14.4	....	.3065	3	D5	189.1,2,*11,12*†	39	10	M	bc
1121CVI	28 07 S	227 34	Do.	15.8	....	13 10 E	3	....	....	....	..	....	....	......	..	C1, D5	....	39	12	MR	bcq
1122CVI	27 11 S	228 33	Aug 29	7.5	....	12 38 E	2	....	....	....	..	....	....	......	..	C1	....	22	10	M	c
1123CVI	27 20 S	228 30	Do.	....	....	....	..	14.2	....	41 35 S	3	14.2	....	.3081	3	D5	189.1,2,*11,12*†	191	13	M	bc
1124CVI	27 26 S	228 26	Do.	16.5	....	13 02 E	3	....	....	....	..	....	....	......	..	C1, D5	....	180	7	M	bc
1125CVI	28 29 S	228 18	Aug 30	6.6	....	13 46 E	3	....	....	....	..	....	....	......	..	C1, D5	....	146	7	MS	bc
1126CVI	29 06 S	228 30	Do.	....	....	....	..	13.8	....	43 57 S	3	13.8	....	.3036	3	D5	189.2,*11,12*	132	8	M	bc
1127CVI	29 17 S	228 38	Do.	15.8	....	13 06 E	2	....	....	....	..	....	....	......	..	C1	....	129	5	M	c
1128CVI	30 19 S	229 50	Aug 31	7.8	....	14 23 E	2	....	....	....	..	....	....	......	..	C1	....	101	4	S	c
1129CVI	30 36 S	230 32	Do.	....	....	....	..	14.2	....	45 34 S	3	14.2	....	.3003	3	D5	189.1,2,*11,12*†	101	13	M	c
1130CVI	31 40 S	233 32	Sep 1	....	....	....	..	14.5	....	46 15 S	1	14.5	....	.2988	1	D5	189.1,2,*11,12*†	90	23	R	cmr
1131CVI	32 04 S	235 03	Sep 2	7.4	....	15 02 E	2	....	....	....	..	....	....	......	..	C1, D5	....	11	20	R	bc
1132CVI	31 59 S	235 38	Do.	....	....	....	..	14.2	....	46 25 S	2	14.2	....	.2945	2	D5	189.1,2,*11,12*†	68	20	MR	bc
1133CVI	31 57 S	235 51	Do.	16.1	....	14 24 E	2	....	....	....	..	....	....	......	..	C1	....	68	20	R	c
1134CVI	31 42 S	236 38	Sep 3	....	....	....	..	14.4	....	46 04 S	3	14.4	....	.2950	3	D5	189.1,2,*11,12*†	73	12	SL	bc
1135CVI	31 41 S	236 48	Do.	16.7	....	14 53 E	3	....	....	....	..	....	....	......	..	C1, D5	....	73	14	SL	bc
1136CVI	31 45 S	238 08	Sep 4	8.9	....	14 53 E	2	....	....	....	..	....	....	......	..	C1, D5	....	73	8	MS	c
1137CVI	31 46 S	238 41	Do.	....	....	....	..	14.2	....	45 37 S	3	14.2	....	.2944	3	D5	189.1,2,*11,12*†	68	7	S	cc
1138CVI	31 46 S	238 58	Do.	15.9	....	14 53 E	3	....	....	....	..	....	....	......	..	C1, D5	....	68	10	S	bc
1139CVI	31 40 S	240 55	Sep 5	9.1	....	15 11 E	1	....	....	....	..	....	....	......	..	C1	....	90	5	S	c
1140CVI	31 36 S	241 32	Do.	....	....	....	..	14.2	....	44 46 S	3	14.2	....	.2961	3	D5	189.1,2,*11,12*†	68	13	S	c
1141CVI	31 34 S	241 43	Do.	15.9	....	14 59 E	3	....	....	....	..	....	....	......	..	C1, D5	....	68	6	S	c
1142CVI	31 29 S	242 24	Sep 6	7.5	....	14 44 E	3	....	....	....	..	....	....	......	..	C1, D5	....	338	16	S	c
1143CVI	31 32 S	242 50	Do.	....	....	....	..	14.1	....	44 34 S	3	14.1	....	.2954	3	D5	189.1,2,*11,12*†	96	7	S	c
1144CVI	31 41 S	245 18	Sep 7	8.6	....	14 53 E	1	....	....	....	..	....	....	......	..	C1	....	68	14	M	c
1145CVI	31 38 S	246 17	Do.	....	....	....	..	14.2	....	44 01 S	2	14.2	....	.2932	2	D5	189.1,2,*11,12*†	68	14	R	cdq
1146CVI	31 29 S	249 57	Sep 8	....	....	....	..	14.1	....	43 14 S	2	14.1	....	.2907	2	D5	189.1,2,*11,12*†	68	20	MR	cd
1147CVI	31 34 S	251 46	Sep 9	....	....	....	..	14.1	....	42 41 S	3	14.1	....	.2917	3	D5	189.1,2,*11,12*†	70	10	MS	cr
1148CVI	31 27 S	253 55	Sep 10	7.0	....	16 49 E	3	....	....	....	..	....	....	......	..	C1, D5	....	101	10	R	bc
1149CVI	31 18 S	255 06	Do.	....	....	....	..	14.0	....	41 40 S	2	14.0	....	.2884	2	D5	189.2,*11,12*	62	20	R	bc
1150CVI	31 15 S	255 26	Do.	15.9	....	16 38 E	2	....	....	....	..	....	....	......	..	C1, D5	....	62	20	R	cqr
1151CVI	30 52 S	257 26	Sep 11	7.5	....	16 56 E	3	....	....	....	..	....	....	......	..	C1, D5	....	45	14	R	bc
1152CVI	30 32 S	257 56	Do.	....	....	....	..	14.2	....	39 51 S	3	14.2	....	.2882	3	D5	189.1,2,*11,12*†	51	12	ML	bc
1153CVI	30 27 S	258 09	Do.	16.2	....	16 47 E	3	....	....	....	..	....	....	......	..	C1, D5	....	51	19	M	bc
1154CVI	29 49 S	259 09	Sep 12	8.9	....	16 45 E	1	....	....	....	..	....	....	......	..	C1	....	0	10	SL	c

FINAL RESULTS OF OCEAN MAGNETIC OBSERVATIONS ON THE CARNEGIE, 1915–1921—*Concluded.*

CRUISE VI, PACIFIC OCEAN, 1920–1921—*Continued.*

Station	Lat.	Long. East of Gr.	Date	Declination L. M. T.		Declination Value	Declination Wt.	Inclination L. M. T.		Inclination Value	Inclination Wt.	Hor. intensity L. M. T.		Hor. intensity Value	Hor. intensity Wt.	Instruments Compass	Instruments Dip Circle	Remarks Course	Remarks Roll	Remarks Sea	Remarks Weather
	° ′	° ′	*1921*	h	h	° ′		h	h	° ′		h	h	c. g. s.				°	°		
1155CVI	29 30 S	259 13	Sep 12	....	....	....	..	14.3	....	37 58 S	3	14.3	....	0.2882	3	D5	189.1,2,*11*,*12*†	349	12	S	bc
1156CVI	29 21 S	259 13	Do.	17.1	....	16 01 E	3	....	....	....	..	....	....	......	..	C1, D5	....	349	7	S	bc
1157CVI	28 29 S	259 06	Sep 13	6.6	....	15 37 E	3	....	....	....	..	....	....	......	..	C1, D5	....	343	8	S	bc
1158CVI	27 34 S	258 58	Do.	....	....	....	..	14.1	....	35 50 S	3	14.1	....	.2928	3	D5	189.1,2,*11*,*12*†	338	10	S	bc
1159CVI	27 20 S	258 51	Do.	16.5	....	15 14 E	3	....	....	....	..	....	....	......	..	C1, D5	....	326	8	M	bc
1160CVI	25 47 S	258 26	Sep 14	7.1	....	14 30 E	2	....	....	....	..	....	....	......	..	C1	....	354	14	M	bc
1161CVI	25 05 S	258 25	Do.	....	....	....	..	13.7	....	33 04 S	2	13.7	....	.2949	2	D5	189.2,*11*,*12*	349	12	M	bc
1162CVI	24 39 S	258 22	Do.	17.2	....	14 26 E	3	....	....	....	..	....	....	......	..	C1, D5	....	349	14	M	bc
1163CVI	22 44 S	258 14	Sep 15	7.2	....	13 43 E	3	....	....	....	..	....	....	......	..	C1, D5	....	349	15	R	bcqr
1164CVI	21 49 S	258 13	Do.	....	....	....	..	14.2	....	28 25 S	2	14.2	....	.3003	2	D5	189.1,2,*11*,*12*†	349	12	R	bc
1165CVI	21 28 S	258 12	Do.	16.9	....	13 20 E	3	....	....	....	..	....	....	......	..	C1, D5	....	349	18	MR	bc
1166CVI	19 47 S	258 01	Sep 16	7.0	....	12 32 E	3	....	....	....	..	....	....	......	..	C1, D5	....	349	10	R	bc
1167CVI	18 54 S	257 57	Do.	....	....	....	..	14.2	....	23 53 S	2	14.2	....	.3042	2	D5	189.1,2,*11*,*12*†	349	11	R	bc
1168CVI	18 33 S	257 54	Do.	17.0	....	12 22 E	3	....	....	....	..	....	....	......	..	C1, D5	....	349	10	R	bc
1169CVI	16 38 S	257 42	Sep 17	8.0	....	11 41 E	1	....	....	....	..	....	....	......	..	C1	....	349	15	R	c
1170CVI	15 56 S	257 41	Do.	....	....	....	..	14.1	....	19 05 S	2	14.1	....	.3107	2	D5	189.1,2,*11*,*12*†	349	15	M	o
1171CVI	15 50 S	257 41	Do.	15.1	....	11 35 E	1	....	....	....	..	....	....	......	..	C1	....	202	15	R	o
1172CVI	13 52 S	257 26	Sep 18	7.6	....	11 11 E	2	....	....	....	..	....	....	......	..	C1, D5	....	349	12	M	bc
1173CVI	13 02 S	257 26	Do.	....	....	....	..	14.2	....	14 10 S	2	14.2	....	.3143	2	D5	189.1,2,*11*,*12*†	0	13	M	bc
1174CVI	12 39 S	257 28	Do.	16.9	....	10 58 E	3	....	....	....	..	....	....	......	..	C1, D5	....	0	12	MR	bc
1175CVI	10 42 S	257 37	Sep 19	6.6	....	10 41 E	3	....	....	....	..	....	....	......	..	C1, D5	....	0	8	MR	bcq
1176CVI	9 47 S	257 44	Do.	....	....	....	..	14.2	....	8 18 S	2	14.2	....	.3220	2	D5	189.1,2,*11*,*12*†	20	14	M	bc
1177CVI	9 32 S	257 51	Do.	16.4	....	10 41 E	3	....	....	....	..	....	....	......	..	C1, D5	....	17	10	M	bc
1178CVI	8 04 S	258 28	Sep 20	6.4	....	10 26 E	3	....	....	....	..	....	....	......	..	C1, D5	....	17	15	MR	bcq
1179CVI	7 17 S	258 46	Do.	....	....	....	..	14.0	....	2 56 S	2	14.0	....	.3256	2	D5	189.1,2,*11*,*12*†	22	12	R	bcq
1180CVI	7 07 S	258 53	Do.	16.3	....	10 25 E	2	....	....	....	..	....	....	......	..	C1, D5	....	34	16	R	bc
1181CVI	5 41 S	259 44	Sep 21	7.8	....	10 07 E	2	....	....	....	..	....	....	......	..	C1	....	28	15	M	c
1182CVI	5 08 S	260 05	Do.	....	....	....	..	13.9	....	1 53 N	2	13.9	....	.3293	2	D5	189.2,*11*,*12*	33	10	M	c
1183CVI	4 50 S	260 12	Do.	16.3	....	10 02 E	3	....	....	....	..	....	....	......	..	C1, D5	....	22	9	M	bcqr
1184CVI	3 31 S	260 59	Sep 22	6.9	....	9 55 E	3	....	....	....	..	....	....	......	..	C1, D5	....	34	10	M	bcqr
1185CVI	3 08 S	261 19	Do.	....	....	....	..	14.1	....	6 05 N	3	14.1	....	.3327	3	D5	189.1,2,*11*,*12*†	39	13	M	bc
1186CVI	2 56 S	261 27	Do.	16.7	....	9 55 E	3	....	....	....	..	....	....	......	..	C1, D5	....	39	6	M	c
1187CVI	1 52 S	261 52	Sep 23	7.1	....	9 44 E	3	....	....	....	..	....	....	......	..	C1, D5	....	22	8	M	c
1188CVI	1 24 S	262 05	Do.	....	....	....	..	14.0	....	10 10 N	3	14.0	....	.3342	3	D5	189.1,2,*11*,*12*†	24	8	S	bc
1189CVI	1 09 S	262 10	Do.	17.0	....	9 35 E	3	....	....	....	..	....	....	......	..	C1, D5	....	28	6	M	b
1190CVI	0 10 S	262 25	Sep 24	6.8	....	9 38 E	2	....	....	....	..	....	....	......	..	C1	....	51	8	S	c
1191CVI	0 04 S	262 37	Do.	11.1	....	9 32 E	2	....	....	....	..	....	....	......	..	C1	....	79	6	S	c
1192CVI	0 04 N	262 50	Do.	....	....	....	..	14.5	....	13 13 N	3	14.5	....	.3358	3	D5	189.1,2,*11*,*12*†	56	8	S	bc
1193CVI	0 44 N	263 57	Sep 25	7.6	....	9 28 E	2	....	....	....	..	....	....	......	..	C1	....	70	8	M	o
1194CVI	0 54 N	264 37	Do.	....	....	....	..	14.3	....	15 46 N	1	14.3	....	.3327	2	D5	189.1,2,*11*,*12*†	72	10	M	o
1195CVI	0 57 N	264 51	Do.	16.3	....	9 16 E	2	....	....	....	..	....	....	......	..	C1	....	79	10	M	c
1196CVI	1 15 N	266 14	Sep 26	7.6	....	9 13 E	2	....	....	....	..	....	....	......	..	C1	....	68	6	M	o
1197CVI	1 21 N	266 54	Do.	....	....	....	..	14.1	....	17 20 N	1	14.1	....	.3366	2	D5	189.1,2,*11*,*12*†	79	12	M	o
1198CVI	2 00 N	268 00	Sep 27	8.2	....	9 04 E	2	....	....	....	..	....	....	......	..	C1	....	84	10	M	c
1199CVI	2 02 N	268 35	Do.	....	....	....	..	14.1	....	19 22 N	3	14.1	....	.3328	3	D5	189.1,2,*11*,*12*†	84	6	M	o
1200CVI	2 20 N	269 54	Sep 28	7.5	....	9 02 E	2	....	....	....	..	....	....	......	..	C1	....	45	8	M	c
1201CVI	2 20 N	270 36	Do.	....	....	....	..	13.8	....	21 51 N	2	13.8	....	.3258	2	D5	189.2,*11*,*12*	90	7	M	o
1202CVI	2 28 N	271 49	Sep 29	6.3	....	8 23 E	3	....	....	....	..	....	....	......	..	C1, D5	....	56	5	S	bc
1203CVI	2 48 N	272 20	Do.	....	....	....	..	14.0	....	22 33 N	3	14.0	....	.3335	3	D5	189.1,2,*11*,*12*†	51	7	S	bc
1204CVI	2 50 N	272 26	Do.	16.8	....	8 11 E	2	....	....	....	..	....	....	......	..	C1	....	62	6	S	c
1205CVI	2 28 N	273 25	Sep 30	8.1	....	8 09 E	2	....	....	....	..	....	....	......	..	C1	....	101	6	S	c
1206CVI	2 22 N	273 52	Do.	....	....	....	..	14.2	....	22 49 N	2	14.2	....	.3278	3	D5	189.1,2,*11*,*12*†	90	5	S	o
1207CVI	2 19 N	274 00	Do.	16.2	....	7 54 E	2	....	....	....	..	....	....	......	..	C1	....	90	6	S	o
1208CVI	2 00 N	275 37	Oct 1	8.1	....	7 50 E	2	....	....	....	..	....	....	......	..	C1, D5	....	56	14	M	c
1209CVI	2 05 N	275 59	Do.	....	....	....	..	14.0	....	22 54 N	3	14.0	....	.3285	3	D5	189.1,2,*11*,*12*†	68	8	M	c
1210CVI	2 10 N	276 12	Do.	16.5	....	7 25 E	2	....	....	....	..	....	....	......	..	C1	....	68	8	S	c
1211CVI	2 40 N	277 26	Oct 2	6.8	....	7 14 E	3	....	....	....	..	....	....	......	..	C1, D5	....	68	10	M	bc
1212CVI	2 56 N	277 59	Do.	....	....	....	..	14.0	....	25 02 N	2	14.0	....	.3254	2	D5	189.1,2,*11*,*12*†	68	18	M	bc

CRUISE VI, PACIFIC OCEAN, 1920–1921—*Concluded.*

	° ′	° ′	1921	h	h	° ′		h	h	° ′		h	h	c.g.s.				°	°		
1213CVI	3 03 N	278 11	Oct 2	16.9	....	6 41 E	3	....	....	....	..	....	....	......	..	C1, D5	....	68	17	M	bc
1214CVI	3 43 N	279 34	Oct 3	8.8	....	6 05 E	1	....	....	....	..	....	....	......	..	C1	....	68	11	M	c
1215CVI	3 53 N	280 00	Do.	....	....	....	..	14.1	....	27 46 N	3	14.1	....	0.3227	3	D5	189.1,2,*11,12*†	68	13	MS	bc
1215CVI	3 59 N	280 14	Do.	16.7	....	5 56 E	3	....	....	....	..	....	....	......	..	C1,D5	....	45	12	M	c
1217CVI	4 51 N	281 19	Oct 4	....	....	....	..	14.1	....	29 50 N	3	14.1	....	.3206	3	D5	189.1,2,*11,12*†	0	9	S	c
1218CVI	5 03 N	281 22	Do.	16.8	....	5 27 E	3	....	....	....	..	....	....	......	..	C1, D5	....	0	8	S	bc
1219CVI	6 09 N	281 38	Oct 5	6.4	....	5 12 E	3	....	....	....	..	....	....	......	..	C1, D5	....	0	6	S	bc
1220CVI	6 40 N	281 38	Do.	....	....	....	..	14.0	....	32 52 N	3	14.0	....	.3209	3	D5	189.1,2,*11,12*†	338	11	S	c
1221CVI	6 46 N	281 38	Do.	16.4	....	4 53 E	3	....	....	....	..	....	....	......	..	C1, D5	....	338	8	S	c
1222CVI[1]	7 34 N	281 16	Oct 6	7.1	....	4 50 E	3	....	....	....	..	....	....	......	..	C1, D5	....	315	8	S	bc

CRUISE VI, ATLANTIC OCEAN, 1921.

	° ′	° ′	1921	h	h	° ′		h	h	° ′		h	h	c.g.s.				°	°		
1223CVI	11 03 N	281 31	Oct 21	6.4	....	4 16 E	3	....	....	....	..	....	....	......	..	C1, D5	....	62	10	M	c
1224CVI	11 37 N	282 39	Do.	....	....	....	..	14.1	....	40 45 N	3	14.1	....	0.3121	3	D5	189.1,2,*11,12*†	62	8	M	bc
1225CVI	11 46 N	283 00	Do.	16.8	....	3 18 E	3	....	....	....	..	....	....	......	..	C1, D5	....	79,28	9	MS	bc
1226CVI	12 12 N	283 50	Oct 22	6.4	....	2 54 E	3	....	....	....	..	....	....	......	..	C1, D5	....	51	11	S	bc
1227CVI	12 30 N	284 05	Do.	....	....	....	..	14.0	....	42 44 N	3	14.0	....	.3084	3	D5	189.1,2,*11,12*†	22	12	M	bc
1228CVI	12 46 N	284 08	Do.	16.8	....	2 51 E	3	....	....	....	..	....	....	......	..	C1, D5	....	22	10	S	bc
1229CVI	13 58 N	284 24	Oct 23	6.6	....	2 25 E	3	....	....	....	..	....	....	......	..	C1, D5	....	34	11	M	bc
1230CVI	14 52 N	284 29	Do.	....	....	....	..	13.4	....	46 01 N	2	13.4	....	.3026	2	D5	189.1,*11,12*	8	17	M	bc
1231CVI	15 16 N	284 30	Do.	16.6	....	2 02 E	3	....	....	....	..	....	....	......	..	C1, D5	....	11	10	M	bc
1232CVI	16 50 N	284 33	Oct 24	7.0	....	1 58 E	3	....	....	....	..	....	....	......	..	C1, D5	....	6	7	M	bc
1233CVI	17 36 N	284 55	Do.	....	....	....	..	14.4	....	49 47 N	3	14.4	....	.2948	3	D5	189.1,2,*11,12*†	22	2	M	bcq
1234CVI	17 46 N	285 00	Do.	16.4	....	1 12 E	3	....	....	....	..	....	....	......	..	C1, D5	....	28	10	M	bcq
1235CVI	18 45 N	285 22	Oct 25	6.7	....	0 44 E	3	....	....	....	..	....	....	......	..	C1, D5	....	45	4	S	bc
1236CVI	19 18 N	285 44	Do.	16.3	....	0 19 E	3	....	....	....	..	....	....	......	..	C1, D5	....	34	4	S	bc
1237CVI	20 20 N	285 59	Oct 26	6.5	....	0 01 E	3	....	....	....	..	....	....	......	..	C1, D5	....	11	6	S	bc
1238CVI	20 55 N	286 04	Do.	....	....	....	..	14.0	....	53 54 N	3	14.0	....	.2805	3	D5	189.1,2,*11,12*†	349	10	S	bc
1239CVI	21 13 N	286 01	Do.	16.6	....	0 25 W	3	....	....	....	..	....	....	......	..	C1, D5	....	349	4	S	bc
1240CVI	22 24 N	286 26	Oct 27	6.8	....	0 59 W	3	....	....	....	..	....	....	......	..	C1, D5	....	73	10	S	bc
1241CVI	23 21 N	286 45	Do.	....	....	....	..	14.1	....	56 51 N	2	14.1	....	.2691	2	D5	189.1,2,*11,12*†	0	14	MR	cq
1242CVI	23 40 N	286 47	Do.	16.3	....	2 01 W	2	....	....	....	..	....	....	......	..	C1, D5	....	0	14	M	bcq
1243CVI	24 45 N	286 56	Oct 28	7.2	....	2 07 W	2	....	....	....	..	....	....	......	..	C1, D5	....	248	17	R	c
1244CVI	24 33 N	286 30	Do.	....	....	....	..	14.0	....	58 00 N	1	14.0	....	.2642	1	D5	189.1,2,*11,12*†	270	17	R	bc
1245CVI	24 32 N	286 21	Do.	16.3	....	1 41 W	2	....	....	....	..	....	....	......	..	C1, D5	....	281	17	R	bc
1246CVI	24 45 N	285 38	Oct 29	7.1	....	1 03 W	2	....	....	....	..	....	....	......	..	C1, D5	....	326	9	RL	bc
1247CVI	25 07 N	285 18	Do.	....	....	....	..	14.2	....	58 19 N	2	14.2	....	.2646	2	D5	189.1,2,*11,12*†	326	8	ML	bcqr
1248CVI	25 12 N	285 14	Do.	15.9	....	1 34 W	2	....	....	....	..	....	....	......	..	C1	....	343	12	L	bc
1249CVI	26 20 N	284 48	Oct 30	6.7	....	1 16 W	3	....	....	....	..	....	....	......	..	C1, D5	....	349	13	L	bc
1250CVI	27 06 N	284 39	Do.	16.4	....	1 44 W	3	....	....	....	..	....	....	......	..	C1, D5	....	11	11	L	bc
1251CVI	28 11 N	284 49	Oct 31	6.8	....	2 03 W	3	....	....	....	..	....	....	......	..	C1, D5	....	17	10	S	bc
1252CVI	28 54 N	285 02	Do.	....	....	....	..	14.3	....	62 19 N	3	14.2	....	.2462	3	D5	189.1,2,*11,12*†	14	17	M	bc
1253CVI	28 59 N	285 04	Do.	15.1	....	2 45 W	2	....	....	....	..	....	....	......	..	C1	....	34	17	M	bc
1254CVI	30 44 N	285 16	Nov 1	7.2	....	3 29 W	2	....	....	....	..	....	....	......	..	C1, D5	....	349	11	R	cq
1255CVI	31 22 N	285 17	Do.	....	....	....	..	13.4	....	64 34 N	2	13.4	....	.2341	2	D5	189.1,*11,12*	6	15	M	bc
1256CVI	31 46 N	285 20	Do.	16.0	....	4 21 W	2	....	....	....	..	....	....	......	..	C1, D5	....	6	22	M	bc
1257CVI	33 33 N	285 51	Nov 2	7.3	....	5 34 W	1	....	....	....	..	....	....	......	..	C1, D5	....	135	15	R	bcq
1258CVI	33 29 N	286 13	Nov 3	6.9	....	5 41 W	2	....	....	....	..	....	....	......	..	C1, D5	....	343	11	L	bc
1259CVI	33 57 N	285 55	Do.	....	....	....	..	14.0	....	66 50 N	3	14.0	....	.2180	3	D5	189.1,2,*11,12*†	338	5	S	bc
1260CVI	34 09 N	285 58	Do.	15.8	....	5 49 W	3	....	....	....	..	....	....	......	..	C1, D5	....	22	8	S	bc
1261CVI	35 17 N	286 23	Nov 4	7.2	....	7 01 W	2	....	....	....	..	....	....	......	..	C1, D5	....	22	13	M	bc
1262CVI	35 12 N	285 59	Do.	....	....	....	..	14.1	....	67 59 N	2	14.1	....	.2100	2	D5	189.1,2,*11,12*†	264	7	M	bc
1263CVI	35 15 N	285 52	Do.	16.0	....	6 37 W	3	....	....	....	..	....	....	......	..	C1, D5	....	338	12	S	bc
1264CVI	36 28 N	285 25	Nov 5	7.0	....	7 14 W	1	....	....	....	..	....	....	......	..	C1, D5	....	338	14	R	bc
1235CVI	36 28 N	285 20	Do.	....	....	....	..	14.0	....	69 05 N	2	14.0	....	.2035	2	D5	189 1.2,*11,12*†	270	16	R	bc
1266CVI	36 25 N	285 10	Do.	15.8	....	6 07 W	3	....	....	....	..	....	....	......	..	C1, D5	....	281	10	MR	bc
1267CVI	36 52 N	284 09	Nov 6	7.0	....	4 56 W	3	....	....	....	..	....	....	......	..	C1, D5	....	292	5	S	b
1268CVI[2]	36 59 N	283 56	Do.	....	....	....	..	8.7	....	69 39 N	3	8.7	....	.1994	3	D5	189.1,*11,12*	292	3	S	b
1269CVI[3]	38 10 N	283 43	Nov 7	7.1 to 9.2		6 20 W	3	....	....	....	..	....	....	......	..	C1, D5	....	Swing	0	S	bcs
1270CVI[3]	38 11 N	283 44	Do.	....	....	....	..	9.4 to 14.0		70 19 N	3	9.4 to 14.0		.1940	3	D5	189.1,*11,12*	Swing	0–1	S	bc
1271CVI[4]	38 07 N	283 28	Nov 9	....	....	....	..	14.2	....	70 17 N	3	14.2	....	.1947	3	D5	189.1,2,*11,12*†	315	0	S	cr
1272CVI[4]	38 25 N	282 44	Nov 10	9.1	....	5 18 W	3	....	....	....	..	....	....	......	..	C1, D5	....	0	0	S	bc

[1] From October 7 to October 19 the *Carnegie* was at Balboa. On October 20 the vessel passed through the Panama Canal.
[2] Off Cape Henry.
[3] Swinging ship in Chesapeake Bay.
[4] On the Potomac River.

SHORE MAGNETIC OBSERVATIONS FOR THE CARNEGIE WORK, 1915–1921.

EXPLANATORY REMARKS.

The following results of shore magnetic observations made during cruises IV, V, and VI of the *Carnegie*, 1915 to 1920, are extracted from Volume IV, Researches of the Department of Terrestrial Magnetism, pages 34 to 97, with some slight corrections due to the adoption of final constants for magnetometers 5 and 25. The results of shore observations made during 1921 appear in this volume for the first time. The same conventions are used as in previous volumes, to which reference may be made if fuller information is desired.

These shore magnetic results were usually obtained in connection with the intercomparisons of ship and land instruments made at every port of call of the vessel. Sometimes additional observations were made in view of the disclosure of local magnetic disturbance or for the purpose of obtaining secular-variation data.

The arrangement of stations is according to decreasing northerly latitude within each country or island group, while the countries are given in alphabetical order for each continent and the island groups are similarly arranged under the head of the ocean within which they lie. Longitudes are given invariably east of Greenwich. All magnetic results are reduced to the magnetic standards of the Department (see p. 35). No corrections have been made for reduction to mean of day, or to any common epoch. The quantities given in the column headed "Value" for each of the three elements are generally means of two or more determinations made at times indicated in the adjoining columns. A number in parentheses under "Local mean time," for example, "13^h5 to 14^h8 (6)," means that six determinations made within the interval are included in the mean. For some comparisons of the marine collimating-compass or deflector it was convenient to make eye-readings of declination at short intervals, usually one minute, for several hours; the mean values of such observations are indicated by use of the abbreviation for diurnal variation (dv), thus: "14^h4 to 17^h2 (dv)."

It should be noted that, as for all previous volumes, the local mean time given for horizontal-intensity observations refers to the mean time of what is defined as one-half set of horizontal-intensity observations, namely, one set of oscillations and one set of deflections, a full set being defined as one set of oscillations, two sets of deflections, and finally a second set of oscillations. The figure in parentheses following the local mean time of the horizontal-intensity observation indicates the number of half-sets involved.

The instrument used for determination of declination or horizontal intensity (or both) is indicated in the column headed "Mag'r." Except for a few values at Colon in 1915 and at San Francisco in 1921, all results tabulated were obtained by the ship's standard magnetometers 5 and 25; since values determined by other instruments were referred to these by the intercomparisons at shore stations, only the results by the standard instruments are included in the table of results.

The heading "Dip circle" is retained to designate the instrument by which the inclination was determined to conform to practice adopted for previous volumes, although only two results given in the table were observed with a dip circle. All other inclinations tabulated were determined by earth inductors. Where dip circles were compared with earth inductors, only the results by the latter are given, since experience with both types of instruments has shown the accuracy and constancy of any correction of the inductor for all values of inclination to be far superior to those of the dip circle.

RESULTS OF SHORE MAGNETIC OBSERVATIONS, 1915-1921.

AFRICA.

British South and Central Africa.

Station	Latitude	Long. East of Gr.	Date	Declination Local mean time	Declination Value	Inclination L. M. T.	Inclination Value	Hor. Intensity L. M. T.	Hor. Intensity Value	Instruments Mag'r	Instruments Dip circle	Obs'r
	° ′	° ′		h h h	° ′	h h	° ′	h h	c. g. s.			
Cape Town, *A*	33 56.1 S	18 29	Apr 30, '20	9.1,11.1	26 03.5 W			9.7,10.7	0.16579	5		C VI
			Do.	12.2,13.7	25 58.4 W			12.6,13.2	.16570	5		C VI
			May 3, 20					13.6,14.8	.16556	25		C VI
			May 4, 20					8.3, 9.7	.16578	25		C VI
			Do.					11.1,11.9	.16562	25		C VI
			Do.	13.4,14.9	25 58.4 W			13.8,14.5	.16551	25		C VI
			Do.	15.3,15.5	25 57.4 W					25		C VI
			May 5, 20	8.6,10.3	26 03.9 W	14.3,14.9	61 29.2 S	9.2, 9.9	.16572	25	EI 7	C VI
			Do.	11.0,11.3	26 03.6 W	15.4,15.7	61 29.9 S			5	EI 25	C VI
Cape Town, *C*	33 56.1 S	18 29	Apr 30, 20	9.1,11.1	26 06.4 W			9.6,10.7	.16551	25		C VI
			Do.	12.2,13.7	26 02.2 W			12.5,13.2	.16538	25		C VI
			May 4, 20	13.4,14.9	26 00.8 W			13.8,14.6	.16514	5		C VI
			Do.	15.3,15.5	26 00.8 W					5		C VI
			May 5, 20	8.6,10.3	26 08.0 W	14.3,14.9	61 30.2 S	9.2, 9.9	.16552	5	EI 25	C VI
			Do.	11.0,11.3	26 07.8 W	15.4,15.7	61 29.6 S			25	EI 7	C VI
			May 6, 20	15.3 to 16.8 (dv)	25 59.9 W	8.5 to		9.4,10.0	.16548	25		C VI
			Do.			14.9 (8)	61 30.4 S	12.8,	.16531	25	EI 25	C VI
			May 7, 20	7.9 to 9.8 (dv)	26 05.4 W	10.8,11.4	61 29.6 S			25	EI 25	C VI
			Do.			12.3	61 29.3 S				EI 25	C VI
			May 12, 20	13.6 to 17.0 (dv)	25 59.9 W					25		C VI

AUSTRALASIA.

Australia.

Station	Latitude	Long. East of Gr.	Date	Declination Local mean time	Declination Value	Inclination L. M. T.	Inclination Value	Hor. Intensity L. M. T.	Hor. Intensity Value	Instruments Mag'r	Instruments Dip circle	Obs'r
	° ′	° ′		h h h	° ′	h h	° ′	h h	c. g. s.			
Watheroo Observatory, *Nm*	30 18.9 S	115 52.6	Sep 14, '20	13.1,14.7	4 20.4 W			13.5,14.3	0.24865	5		C VI
			Sep 15, 20	8.6,10.5	4 23.5 W			9.1,10.0	.24905	5		C VI
			Do.	12.9,14.6	4 20.2 W			13.3,14.2	.24879	5		C VI
Watheroo Observatory, *Nw*	30 18.9 S	115 52.6	Sep 16, 20			13.0 to 15.1 (6)	63 55.9 S				EI 7	C VI
Watheroo Observatory, *Sm*	30 18.9 S	115 52.6	Sep 13, 20	8.9,10.7	4 26.6 W			9.4,10.3	.24884	5		C VI
			Do.	13.3,15.3	4 19.8 W			13.8,14.9	.24880	5		C VI
			Sep 14, 20	8.5,10.8	4 26.0 W			9.1,10.3	.24884	5		C VI
			Sep 15, 20					15.2	.24874	5		C VI
Watheroo Observatory, *Sw*	30 18.9 S	115 52.6	Sep 16, 20			8.8 to 11.4 (6)	63 56.1 S				EI 7	C VI
Cottesloe, *A*	31 59.3 S	115 44	Sep 7, 20	16.7	4 44.9 W			9.9,16.1	.23934	25		C VI
			Sep 8, 20					16.2	.23919	25		C VI
			Sep 9, 20	9.3,10.4, 10.6	4 49.4 W			9.8	.23921	25		C VI
			Do.	11.0,13.0	4 47.5 W			11.9,12.6	.23900	25		C VI
			Do.	13.9	4 48.7 W			14.7,15.4	.23861	5		C VI
			Sep 10, 20	9.1,11.7,12.9	4 49.2 W			9.5,10.4	.23912	5		C VI
			Do.	14.3,14.4	4 47.6 W			13.2,13.9	.23880	5		C VI
			Sep 13, 20			10.4 to 12.7 (6)	65 21.8 S				EI 25	C VI
			Do.			14.2 to 15.7 (6)	65 22.7 S				EI 7	C VI
			Sep 21, 20	6.7 to 8.5 (dv)	4 50.5 W					25		C VI
			Sep 23, 20	16.0 to 17.7 (dv)	4 47.1 W			14.3,15.4	.23902	25		C VI
			Sep 28, 20	16.6 to 17.4 (dv)	4 44.3 W					25		C VI
			Sep 29, 20	5.9 to 7.9 (dv)	4 44.3 W					25		C VI
Cottesloe, *B*	31 59.3 S	115 44	Sep 7, 20	16.7	4 46.4 W			10.0,16.1	.23926	5		C VI
			Sep 8, 20					16.2	.23920	5		C VI
			Sep 9, 20	9.3,10.4,10.6	4 50.5 W			9.8	.23922	5		C VI
			Do.	11.0,13.0	4 48.4 W			11.9,12.6	.23900	5		C VI
			Do.	13.9	4 50.0 W			14.7,15.3	.23862	25		C VI
			Sep 10, 20	9.1,11.7,12.9	4 50.9 W			9.5,10.4	.23906	25		C VI
			Do.	14.3,14.4	4 49.6 W			13.2,13.9	.23874	25		C VI
			Sep 13, 20			10.4 to 12.7 (6)	65 23.4 S				EI 7	C VI
			Do.			14.2 to 15.8 (6)	65 23.0 S				EI 25	C VI
			Sep 14, 20			8.8 to 14.2 (7)	65 22.9 S	10.0,11.5	.23918	25	EI 25	C VI
			Do.					13.6	.23892	25		C VI
			Sep 16, 20					9.8,10.5	.23927	25		C VI
			Do.					12.0,13.2	.23899	25		C VI
			Do.					14.0,14.8	.23901	25		C VI
			Do.					15.5	.23897	25		C VI

AUSTRALASIA.

AUSTRALIA—*Concluded.*

Station	Latitude	Long. East of Gr.	Date	Declination: Local mean time	Declination: Value	Inclination: L. M. T.	Inclination: Value	Hor. Intensity: L. M. T.	Hor. Intensity: Value	Instruments: Mag'r	Instruments: Dip circle	Obs'r
	° ′	° ′		h h h	° ′	h h	° ′	h h	c. g. s.			
Cottesloe, *B—Concluded*	31 59.3 S	115 44	Sep 17, '20	....	....	....	....	9.1, 9.7	0.23916	25	....	C VI
			Do.	....	....	....	....	10.2,10.7	.23936	25	....	C VI
			Do.	....	....	....	....	12.0,12.6	.23880	25	....	C VI
			Do.	....	....	....	....	13.4,14.0	.23889	25	....	C VI
			Sep 21, 20	10.7 to 13.0 (dv)	4 50.0 W	....	....	....	......	25	....	C VI
			Sep 23, 20	....	....	....	....	14.3,15.3	.23887	5	....	C VI
			Sep 24, 20	....	....	12.0 to 14.5 (6)	65 23.8 S	....	......	....	EI 25	C VI
			Sep 25, 20	....	....	8.9, 9.3	65 23.2 S	....	......	....	EI 25	C VI
						9.6	65 23.0 S	....	......	....	EI 25	C VI

NEW ZEALAND.

Station	Latitude	Long. East of Gr.	Date	Declination: Local mean time	Declination: Value	Inclination: L. M. T.	Inclination: Value	Hor. Intensity: L. M. T.	Hor. Intensity: Value	Instruments: Mag'r	Instruments: Dip circle	Obs'r
	° ′	° ′		h h h	° ′	h h	° ′	h h	c. g. s.			
Christchurch, *East Pier*	43 31.8 S	172 37	Nov 10, '15	15.3	16 52.1 E	....	....	15.9,17.1	0.22417	5	....	C IV
			Nov 11, 15	10.0	16 43.7 E	....	....	10.7,12.1	.22368	5	....	C IV
			Do.	14.5,14.9	16 51.6 E	....	....	15.6,16.5	.22404	5	....	C IV
			Nov 12, 15	9.1,11.9	16 44.2 E	....	....	9.7,10.9	.22358	25	....	C IV
			Nov 15, 15	8.9,11.2	16 44.0 E	....	....	9.5,10.6	.22371	25	....	C IV
			Do.	11.9,12.3	16 48.0 E	....	....	16.1,17.2	.22414	25	....	C IV
			Do.	18.0,18.3	16 49.8 E	....	....	....	......	5	....	C IV
			Nov 23, 15	....	....	....	....	10.3 to 17.2 (5)	.22393	5	....	C IV
			Nov 24, 15	....	....	....	....	9.7,10.8	.22361	5	....	C IV
			Do.	....	....	....	....	14.4,15.2	.22383	5	....	C IV
			Do.	....	....	....	....	15.8,16.6	.22408	5	....	C IV
			Nov 25, 15	....	....	....	....	8.8 to 17.3 (12)	.22386	5	....	C IV
			Nov 26, 15	9.2,11.0,11.4	16 43.9 E	....	....	9.6 to		5	....	C IV
			Do.	14.4,14.8,16.7	16 53.0 E	....	....	16.3 (6)	.22388	5	....	C IV
			Nov 2, 20	....	....	....	....	10.8,12.3	.22266	5	....	C VI
			Do.	....	....	....	....	14.7,15.6	.22282	5	....	C VI
			Do.	....	....	....	....	16.4	.22277	5	....	C VI
			Nov 3, 20	12.8 to 16.1 (6)	17 06.2 E	....	....	10.9	.22254	5	....	C VI
Christchurch, *West Pier*	43 31.8 S	172 37	Nov 14, 15	....	....	6.3 to 10.8 (12)	68 01.7 S	....	......	....	EI 25	C IV
			Nov 5, 20	....	....	0.5 to 2.3 (6)	68 10.6 S	....	......	....	EI 25	C VI
Christchurch, *Brass Pipe*	43 31.8 S	172 37	Nov 8, 15	....	....	....	....	14.8,16.0	.22406	5	....	C IV
			Nov 9, 15	9.0,11.3,11.8	16 43.9 E	....	....	9.7,10.8	.22332	5	....	C IV
			Nov 10, 15	8.7,11.0	16 43.6 E	....	....	9.3,10.3	.22360	5	....	C IV
			Do.	11.8,12.1	16 45.8 E	....	....	....	......	5	....	C IV
			Do.	15.3	16 51.1 E	....	....	15.9,17.1	.22406	25	....	C IV
			Nov 11, 15	10.0,14.5,14.9	16 48.8 E	....	....	10.7,12.1	.22361	25	....	C IV
			Do.	....	....	....	....	15.6,16.5	.22412	25	....	C IV
			Nov 14, 15	....	....	6.3 to 10.8 (12)	68 04.1 S	....	......	....	EI 3	C IV
			Nov 15, 15	18.1,18.3	16 48.5 E	....	....	....	......	25	....	C IV
			Nov 16, 15	....	....	8.8 to 11.9 (12)	68 05.1 S	....	......	....	EI 3	C IV
			Nov 18, 15	5.4 to 7.8 (dv)	16 43.7 E	....	....	....	......	25	....	C IV
			Do.	14.5 to 16.5 (dv)	16 52.2 E	....	....	....	......	25	....	C IV
			Nov 19, 15	9.8 to 12.1 (dv)	16 45.8 E	....	....	....	......	25	....	C IV
			Do.	13.8 to 15.9 (dv)	16 51.9 E	....	....	....	......	25	....	C IV
			Nov 20, 15	10.8	16 46.1 E	....	....	....	......	25	....	C IV
			Do.	14.4 to 17.2 (7)	16 51.6 E	....	....	....	......	25	....	C IV
			Nov 22, 15	8.6,10.0,10.6	16 43.5 E	....	....	8.8 to		5	....	C IV
			Do.	14.4,15.9	16 51.0 E	....	....	15.5 (8)	.22380	5	....	C IV
			Nov 26, 15	9.2,11.0,11.4	16 44.4 E	....	....	9.6 to		25	....	C IV
			Do.	14.4,14.8,16.7	16 50.3 E	....	....	16.3 (6)	.22387	25	....	C IV
			Nov 29, 15	14.2 to 16.1 (9)	16 48.8 E	....	....	....	......	25	....	C IV
			Apr 4, 16	11.7,16.6	16 49.8 E	....	....	12.3,16.2	.22372	5	....	C IV
			Apr 5, 16	12.0,12.3	16 50.7 E	....	....	10.4,11.6	.22348	5	....	C IV
			Do.	14.2,16.3	16 51.0 E	....	....	14.6,15.9	.22375	5	....	C IV
			Apr 6, 16	12.0	16 51.3 E	....	....	12.4	.22368	25	....	C IV
			Do.	15.1,15.4	16 53.3 E	....	....	14.6,15.8	.22382	25	....	C IV
			Apr 7, 16	10.2	16 44.6 E	....	....	9.8	.22341	25	....	C IV
			Do.	10.6,12.5	16 49.0 E	....	....	11.1,12.1	.22352	25	....	C IV
			Apr 8, 16	10.3,12.0	16 47.2 E	....	....	10.8,11.6	.22352	25	....	C IV
			Apr 10, 16	9.4,11.2	16 46.7 E	....	....	9.7 to		25	....	C IV
			Do.	12.6,15.2	16 51.5 E	....	....	14.9 (6)	.22364	25	....	C IV
			Apr 11, 16	6.9 to 10.5 (dv)	16 44.5 E	....	....	....	......	25	....	C IV

AUSTRALASIA.

NEW ZEALAND—*Continued.*

Station	Latitude	Long. East of Gr.	Date	Declination: Local mean time	Declination: Value	Inclination: L. M. T.	Inclination: Value	Hor. Intensity: L. M. T.	Hor. Intensity: Value	Instruments: Mag'r	Instruments: Dip circle	Obs'r
	° ′	° ′		h h h	° ′	h h	° ′	h h	c. g. s.			
Christchurch, *Brass Pipe—Concluded*	43 31.8 S	172 37	Apr 12, '16	9.3,10.9,12.4	16 47.9 E			9.6 to		25		C IV
			Do.	15.1,16.4	16 51.6 E			16.1 (8)	0.22362	25		C IV
			Apr 13, 16	9.5,11.3	16 45.6 E			9.8 to		25		C IV
			Do.	12.6,15.8	16 50.1 E			15.4 (6)	.22370	25		C IV
			Apr 14, 16	9.3,10.6	16 45.9 E			9.6,10.2	.22382	25		C IV
			Apr 17, 16	9.8	16 45.3 E					25		C IV
			Do.	14.2,16.2	16 49.4 E			14.6,15.7	.22382	5		C IV
			Apr 18, 16	7.7 to 11.0 (dv)	16 47.5 E					25		C IV
			Apr 19, 16	8.9 to 11.7 (dv)	16 47.3 E					25		C IV
			Do.	13.7	16 52.5 E					25		C IV
			Apr 20, 16	9.1 to 12.6 (dv)	16 47.2 E					25		C IV
			Apr 24, 16	9.5,11.4	16 47.0 E			9.8,11.1	.22349	25		C IV
			Apr 26, 16	9.9,11.3	16 50.3 E			10.3 to		25		C IV
			Do.	12.6,15.4	16 51.8 E			15.1 (6)	.22286	25		C IV
			Apr 27, 16	9.4,10.8	16 47.5 E			9.7 to		25		C IV
			Do.	12.2,15.5	16 49.9 E			15.2 (6)	.22335	25		C IV
			Apr 28, 16	9.5,10.8	16 49.0 E	14.7 to 16.4 (6)	68 05.8 S	9.8,10.5	.22326	25	EI 25	C IV
			Apr 29, 16			9.4 to 11.9 (8)	68 07.6 S				EI 25	C IV
			May 2, 16			8.7 to 12.5 (13)	68 05.2 S				EI 3	C IV
			Oct 26, 20	15.4	17 05.4 E			15.9	.22292	5		C VI
			Oct 27, 20	11.0,12.6,15.2	17 03.2 E			11.5,12.1	.22248	5		C VI
			Do.					15.7	.22293	5		C VI
			Oct 28, 20	9.8,11.8	17 00.0 E			10.5,11.4	.22245	25		C VI
			Do.	12.2,12.3	17 05.4 E			14.6,15.2	.22289	25		C VI
			Do.	16.0,16.2	17 05.1 E					5		C VI
			Oct 29, 20	6.2 to 7.8 (dv)	16 56.8 E					25		C VI
			Nov 7, 20					6.8, 8.4	.22234	5		C VI
Christchurch, *Jarrah Peg*	43 31.8 S	172 37	Nov 7, 15			6.2 to 9.9 (10)	68 04.9 S				EI 25	C IV
			Nov 8, 15			9.6, 9.9	68 04.4 S	10.6,11.4	.22333	25	EI 25	C IV
			Do.			11.9,12.1	68 04.2 S	14.8,16.0	.22389	25	EI 25	C IV
			Nov 9, 15	9.0,11.3,11.8	16 44.8 E			9.6,10.8	.22341	25		C IV
			Nov 10, 15	8.7,11.0	16 43.2 E			9.3,10.3	.22346	25		C IV
			Do.	11.7,12.1	16 46.8 E					25		C IV
			Nov 12, 15	8.1,11.9	16 44.6 E			9.7,10.9	.22355	5		C IV
			Nov 15, 15	8.9,11.2	16 45.8 E			9.5,10.5	.22376	5		C IV
			Do.	11.9,12.3	16 49.6 E			16.2,17.2	.22427	5		C IV
			Nov 16, 15			8.8 to 11.9 (12)	68 04.3 S				EI 25	C IV
			Do.			13.4 to 16.3 (12)	68 04.0 S				EI 3	C IV
			Nov 17, 15	9.4,11.0	16 46.7 E			10.4 to		25		C IV
			Do.	13.3,14.8	16 54.2 E			15.9 (7)	.22354	25		C IV
			Do.	16.2 to 17.9 (dv)	16 53.1 E					25		C IV
			Nov 23, 15			9.6 to 13.0 (10)	68 03.4 S				EI 25	C IV
			Nov 24, 15			8.8 to 11.6 (5)	68 04.4 S				EI 25	C IV
			Nov 29, 15	14.2 to 16.1 (9)	16 52.3 E					5		C IV
			Apr 4, 16	11.7,16.6	16 50.2 E			12.3,16.2	.22366	25		C IV
			Apr 5, 16	12.0,12.3	16 51.2 E			10.4,11.6	.22339	25		C IV
			Do.	14.2,16.3	16 52.1 E			14.6,15.9	.22370	25		C IV
			Apr 6, 16	12.0,15.1,15.4	16 53.1 E			12.4,14.6	.22374	5		C IV
			Apr 7, 16	10.2,10.6,12.5	16 48.0 E			9.8,11.1	.22338	5		C IV
								12.1	.22362	5		C IV
			Do.	15.1 to 17.4 (dv)	16 53.8 E					25		C IV
			Apr 11, 16	13.9 to 15.3 (dv)	16 52.9 E					25		C IV
			Apr 17, 16	14.2,16.2	16 50.9 E			14.6,15.7	.22381	25		C IV
			Apr 18, 16	13.8 to 17.1 (dv)	16 51.8 E					25		C IV
			Apr 28, 16			14.7 to 16.4 (6)	68 06.6 S				EI 3	C IV
			Apr 29, 16			9.5 to 11.9 (8)	68 08.5 S				EI 3	C IV
			May 2, 16			8.7 to 16.2 (17)	68 04.3 S	15.4	.22360	25	EI 25	C IV
			May 3, 16			8.5 to 16.1 (8)	68 04.4 S	9.2 to 15.6 (5)	.22355	25	EI 25	C IV
			May 4, 16			9.6,11.6	68 05.4 S	10.3,11.0	.22338	25	EI 25	C IV
			Oct 26, 20	15.4	17 06.5 E			15.9	.22297	25		C VI
			Oct 27, 20	11.0,12.6	17 04.2 E			11.6,12.1	.22251	25		C VI
			Do.	15.2,16.3,16.4	17 06.4 E			15.7	.22289	25		C VI
			Oct 28, 20	9.9,11.3	17 01.0 E			10.5,11.3	.22238	5		C VI

AUSTRALASIA.

NEW ZEALAND—*Concluded.*

Station	Latitude	Long. East of Gr.	Date	Declination: Local mean time	Declination: Value	Inclination: L. M. T.	Inclination: Value	Hor. Intensity: L. M. T.	Hor. Intensity: Value	Instruments: Mag'r	Instruments: Dip circle	Obs'r
	° ′	° ′		h h h	° ′	h h	° ′	h h	c. g. s.			
Christchurch, *Jarrah Peg—Concluded*	43 31.8 S	172 37	Oct 28, '20	12.2, 12.3	17 08.1 E			14.6, 15.2	0.22288	5		C VI
			Do.	16.0, 16.2	17 06.0 E					25		C VI
			Oct 29, 20	5.6	17 00.3 E					25		C VI
			Do.					12.5, 14.7	.22266	5		C VI
			Do.					15.5	.22291	5		C VI
			Oct 30, 20					9.8, 10.3	.22244	5		C VI
			Do.					11.1, 12.4	.22246	5		C VI
			Oct 31, 20			6.6 to 9.1 (6)	68 10.1 S				EI 25	C VI
			Nov 4, 20	14.9, 15.0, 15.4	17 08.3 E					5		C VI
			Do.	15.6, 15.9, 16.1	17 08.7 E					5		C VI
			Nov 11, 20	16.8 to 17.7 (dv)	17 06.1 E					25		C VI

NORTH AMERICA.

CENTRAL AMERICA.

Station	Latitude	Long. East of Gr.	Date	Declination: Local mean time	Declination: Value	Inclination: L. M. T.	Inclination: Value	Hor. Intensity: L. M. T.	Hor. Intensity: Value	Instruments: Mag'r	Instruments: Dip circle	Obs'r
	° ′	° ′		h h h	° ′	h h	° ′	h h	c. g. s.			
Colon, *Washington*	9 22.0 N	280 05	Mar 27, '15	11.9, 14.5	4 45.9 E			13.0, 13.9	0.32328	21		C IV
			Mar 28, 15			9.0	36 02.4 N				21.(133)4)	C IV
Colon, *Sweetwater, A*	9 21.3 N	280 03	Mar 27, 15	13.5 to 14.8 (6)	4 58.8 E					5		C IV
			Do.	15.2 to 16.5 (6)	4 59.1 E					25		C IV
			Mar 29, 15					8.8, 9.8	.32200	25		C IV
			Do.					10.6, 11.6	.32216	25		C IV
			Do.					13.0, 14.0	.32196	5		C IV
			Do.					15.1, 16.0	.32172	5		C IV
			Mar 31, 15			13.0 to 14.8 (6)	36 01.7 N				EI 3	C IV
			Do.			15.2 to 16.2 (6)	36 02.9 N				EI 25	C IV
			Apr 1, 15			10.1 to 16.2 (8)	36 01.7 N	10.8 to 15.5 (6)	.32187	25	EI 25	C IV
			Apr 2, 15			9.0 to 16.6 (12)	36 01.8 N	13.6, 14.4	.32176	25	EI 25	C IV
			Do.					15.2, 16.2	.32156	25		C IV
Colon, *Sweetwater, B*	9 21.3 N	280 03	Mar 27, 15	13.5 to 14.8 (6)	4 59.9 E					25		C IV
			Do.	15.2 to 16.5 (6)	5 00.3 E					5		C IV
			Mar 29, 15					8.8, 9.9	.32216	5		C IV
			Do.					10.6, 11.6	.32206	5		C IV
			Do.					13.0, 14.0	.32212	25		C IV
			Do.					15.1, 16.0	.32180	25		C IV
			Mar 30, 15					9.7 to 14.8 (5)	.32204	5		C IV
			Mar 31, 15			13.0 to 14.8 (6)	36 00.5 N				EI 25	C IV
			Do.			15.2 to 16.2 (6)	36 00.9 N				EI 3	C IV
			Apr 5, 15	15.4 to 17.2 (dv)	4 58.8 E					5		C IV
			Apr 6, 15	7.7 to 9.0 (dv)	5 00.5 E					5		C IV
			Do.	10.8 to 14.2 (4)	4 59.2 E					5		C IV
Colon, *Sweetwater, C*	9 21.3 N	280 03	Oct 12, 21	9.9, 11.3	5 17.5 E	12.8, 13.0	37 04.2 N	10.3, 11.0	.31776	25	EI 25	C VI
Cristobal, *A*	9 20.7 N	280 06	May 4, 18			11.2 to 14.7 (12)	36 38.2 N				EI 25	C V
			Do.			15.4 to 17.0 (8)	36 37.5 N				EI 3	C V
			May 6, 18			9.4, 9.6	36 35.0 N				EI 3	C V
			Do.			9.8, 10.0	36 35.2 N				EI 3	C V
			May 8, 18					10.8 to 16.6 (8)	.32107	25		C V
Cristobal, *B*	9 20.7 N	280 06	May 4, 18			11.2 to 14.7 (12)	36 38.7 N				EI 3	C V
			Do.			15.4 to 17.0 (8)	36 40.6 N				EI 25	C V
			May 6, 18			9.3 to 16.0 (12)	36 38.0 N	12.1, 14.8	.32122	25	EI 25	C V
			May 7, 18			10.5 (4)	36 35.2 N	10.3 to 17.2 (7)	.32145	25	EI 25	C V
			May 8, 18					9.0, 9.8	.32165	25		C V
Old Panama	9 00.2 N	280 31	Oct 17, 21	9.3, 10.6	5 26.2 E	11.2, 11.4	36 49.4 N	9.7, 10.3	.31850	25	EI 25	C VI

NORTH AMERICA.

UNITED STATES.

Station	Latitude	Long. East of Gr.	Date	Declination Local mean time	Declination Value	Inclination L. M. T.	Inclination Value	Hor. Intensity L. M. T.	Hor. Intensity Value	Instruments Mag'r	Instruments Dip circle	Obs'r
	° ′	° ′		h h h	° ′	h h	° ′	h h	c. g. s.			
Dutch Harbor, *A*	53 54.2 N	193 28	Jul 22, '15	15.4,18.0	16 08.4 E			16.0,17.5	0.20786	25		C IV
			Jul 23, 15	14.1,17.0	16 07.7 E			14.5,16.6	.20772	25		C IV
			Jul 24, 15	8.6,11.2	16 16.2 E			9.0,10.8	.20772	25		C IV
			Do.	11.7	16 12.4 E			13.6,14.6	.20774	5		C IV
			Do.	15.4,15.5,16.6	16 09.5 E					5		C IV
			Jul 26, 15	8.5,10.4,10.8	16 13.9 E			8.9 to		5		C IV
			Do.	13.5 to 16.2 (4)	16 07.8 E			17.3 (8)	.20785	5		C IV
			Jul 27, 15	8.5,10.0,11.5	16 15.9 E			8.8, 9.5	.20771	5		C IV
			Do.					10.3,11.1	.20754	5		C IV
			Do.	13.7 to 18.5 (dv)	16 09.5 E					25		C IV
			Jul 28, 15			10.6 to						
						15.8 (12)	66 32.4 N				EI 25	C IV
			Do.			16.7 (4)	66 32.4 N				EI 3	C IV
			Jul 29, 15			8.3 to						
						10.8 (9)	66 31.8 N				EI 3	C IV
			Do.			13.4,13.8	66 32.8 N	14.4,15.6	.20767	25	EI 25	C IV
			Do.			16.3,16.6	66 31.4 N				EI 25	C IV
			Jul 30, 15			8.2 to		9.1 to				
						17.6 (10)	66 32.3 N	17.2 (8)	.20772	25	EI 25	C IV
			Jul 31, 15					9.0	.20785	25		C IV
			Do.	10.4,11.8	16 12.7 E	8.3, 8.6	66 31.7 N	10.8,11.4	.20776	25	EI 25	C IV
			Do.			9.9,10.1	66 31.1 N				EI 25	C IV
Dutch Harbor, *B*[1]	53 54.2 N	193 28	Jul 22, 15	15.4,18.0	16 28.0 E			16.1,17.5	.20932	5		C IV
			Jul 23, 15	14.1,17.0	16 26.6 E			14.5,16.6	.20929	5		C IV
			Jul 24, 15	8.6,11.2	16 35.6 E			9.1,10.8	.20922	5		C IV
			Do.	11.7	16 31.0 E			13.6,14.7	.20919	25		C IV
			Jul 26, 15	8.5,10.4,10.8	16 33.2 E			8.9,10.0	.20934	25		C IV
			Do.	13.5,13.8	16 26.1 E			11.2,12.1	.20923	25		C IV
			Jul 28, 15			10.6 to						
						15.8 (12)	66 16.4 N				EI 3	C IV
			Do.			16.7 (4)	66 17.1 N				EI 25	C IV
			Jul 29, 15			8.3 to						
						10.8 (9)	66 16.5 N				EI 25	C IV
Dutch Harbor, *C. and G S.*[1]	53 53.4 N	193 28	Jul 26, 15	15.9,18.4	17 16.0 E			16.7,17.8	.20926	25		C IV
			Jul 27, 15			9.8	66 31.8 N				189.1256	C IV
San Rafael	37 58.6 N	237 27	Mar 18, 21	10.5,11.9	18 20.0 E	14.6,14.7	62 13.4 N	11.0,11.6	.24736	25	EI 25	C VI
Goat Island, *A*	37 48.7 N	237 38	Sep 27, 16			9.6 to						
						15.1 (13)	62 06.4 N				EI 25	C IV
			Do.			16.2,16.5	62 04.4 N				EI 3	C IV
			Sep 28, 16			9.0 to						
						15.1 (14)	62 05.7 N				EI 3	C IV
			Sep 29, 16	9.7,12.1,13.3	18 17.2 E			10.3,11.6	.24990	5		C IV
			Do.	15.5,15.9,16.2	18 15.2 E			13.9,15.0	.25017	5		C IV
			Oct 3, 16	9.9,15.7	18 18.8 E			11,2,14.5	.24982	5		C IV
			Oct 4, 16	9.0,11.0,11.3	18 19.0 E			9.5 to				
								16.1 (6)	.24994	25		C IV
			Do.	14.0,14.4,16.6	18 15.7 E					25		C IV
			Oct 5, 16	14.1 to 17.0 (dv)	18 14.8 E	8.8,10.6	62 04.6 N	9.6,12.6	.24986	25	EI 25	C IV
			Do.			11.4,13.9	62 05.0 N				EI 25	C IV
			Oct 6, 16			9.0 to						
						15.6 (8)	62 07.8 N	10.0,11.5	.24966	25	EI 25	C IV
			Oct 9, 16	8.9,10.5,....	18 21.2 E			9.3 to		25		C IV
			Do.	12.0,14.4	18 17.9 E			14.0 (6)	.24960	25		C IV
			Oct 10, 16	9.9,12.2,14.8	18 15.6 E			10.4,11.7	.24982	25		C IV
			Do.					13.5	.24955	25		C IV
			Oct 11, 16	9.0,11.2	18 18.6 E			9.5 to		25		C IV
			Do.	13.3,14.8	18 16.0 E			14.4 (6)	.24966	25		C IV
			Oct 16, 16			9.1 to						
						15.4 (8)	62 05.7 N	10.4,11.4	.24978	25	EI 25	C IV
			Do.					14.0	.24976	25		C IV
			Oct 17, 16	8.8,10.7	18 18.1 E			9.8 to		25		C IV
			Do.	13.4,15.2	18 15.8 E			14.9 (5)	.24990	25		C IV
			Oct 18, 16	9.4,11.2	18 18.6 E			9.9 to		25		C IV
			Do.	13.6,15.3	18 16.1 E			14.9 (6)	.24993	25		C IV
			Oct 19, 16	8.3, 9.9,11.5	18 18.3 E			8.7, 9.5	.25000	25		C IV
			Do.	14.3 to 16.9 (dv)	18 14.5 E			10.3,11.1	.25002	25		C IV
			Oct 20, 16					9.3,10.1	.24996	25		C IV
			Do.					11.1,12.7	.25010	25		C IV
			Oct 23, 16	6.9 to 9.5 (dv)	18 16.9 E					5		C IV
			Oct 25, 16			8.9 to						
						14.0 (13)	62 05.3 N				EI 25	C IV
			Oct 26, 16	8.0 to 9.8 (dv)	18 20.6 E					25		C IV

[1]Local disturbance

NORTH AMERICA.

UNITED STATES—*Concluded.*

Station	Latitude	Long. East of Gr.	Date	Declination Local mean time	Declination Value	Inclination L. M. T.	Inclination Value	Hor. Intensity L. M. T.	Hor. Intensity Value	Instruments Mag'r	Instruments Dip circle	Obs'r
	° ′	° ′		h h h	° ′	h h	° ′	h h	c. g. s.			
Goat Island, *B*	37 48.7 N	237 38	Sep 27, '16	....	....	9.6 to 15.1 (13)	62 05.7 N	....	......	....	EI 3	C IV
			Do.	....	....	16.2,16.5	62 04.8 N	....	......	....	EI 25	C IV
			Sep 28, 16	....	....	9.0 to 15.1 (14)	62 05.4 N	....	......	....	EI 25	C IV
			Sep 29, 16	9.7,12.2,13.3	18 16.4 E	....	....	10.3,11.6	0.24980	25	....	C IV
			Do.	15.5,15.9,16.2	18 15.0 E	....	....	13.9,15.0	.25006	25	....	C IV
			Oct 3, 16	9.9,15.7	18 17.0 E	....	....	11.1,14.5	.24984	25	....	C IV
			Oct 4, 16	9.0,11.0,11.3	18 18.7 E	....	....	9.5 to 16.2 (6)	.24988	5	....	C IV
			Do.	14.0,14.4,16.6	18 15.2 E	....	....	....	......	5	....	C IV
			Oct 13, 16	12.8 to 15.5 (10)	18 13.9 E	....	....	....	......	25	....	C IV
			Oct 25, 16	....	....	8.9 to 14.0 (13)	62 04.6 N	....	......	....	EI 3	C IV
San Francisco, *Fort Scott, A*	37 48.7 N	237 31	Feb 26, 21	10.8,12.7	18 08.0 E	....	....	11.3,12.2	.24714	5	....	C VI
			Feb 28, 21	13.3,13.4,13.8	18 05.4 E	....	....	9.3,10.1	.24738	5	....	C VI
			Do.	14.0,14.5,14.7	18 04.5 E	....	....	10.9,11.7	.24714	5	....	C VI
			Do.	15.1,15.3	18 05.2 E	....	....	....	......	26	....	C VI
			Do.	15.6,15.8	18 05.4 E	....	....	....	......	26	....	C VI
			Mar 1, 21	13.0,13.2	18 05.4 E	....	....	9.1,10.0	.24740	26	....	C VI
			Do.	13.5,13.7	18 05.8 E	....	....	10.8,11.6	.24736	26	....	C VI
			Do.	....	....	....	....	14.1,14.8	.24727	26	....	C VI
			Mar 2, 21	....	....	11.1 to 13.3 (6)	62 16.8 N	....	......	....	EI 25	C VI
			Do.	....	....	13.9 to 15.2 (6)	62 16.1 N	....	......	....	EI 26	C VI
			Mar 3, 21	13.4,13.6,14.0	18 06.8 E	....	....	9.5,10.6	.24729	5	....	C VI
			Do.	14.3,14.7,14.8	18 06.6 E	....	....	11.3,12.9	.24704	5	....	C VI
			Do.	15.4,15.6	18 06.4 E	....	....	....	......	5	....	C VI
			Mar 4, 21	....	....	....	....	10.0,11.8	.24722	5	....	C VI
			Do.	....	....	....	....	13.9,14.7	.24725	5	....	C VI
			Do.	....	....	....	....	15.2	.24726	5	....	C VI
			Mar 7, 21	....	....	....	....	9.4 to 15.3 (7)	.24716	5	....	C VI
			Mar 8, 21	....	....	....	....	13.9,14.6	.24726	5	....	C VI
			Mar 9, 21	....	....			15.1	.24739	5	....	C VI
			Mar 10, 21	....	....	9.8 to 15.3 (9)	62 15.7 N	10.3 to 14.9 (6)	.24724	5	EI 25	C VI
			Mar 15, 21	10.5 to 13.5 (dv)	18 06.9 E	11.0 to 13.9 (7)	62 16.7 N	....	......	....	EI 7	C VI
						....	....	....	......	25	....	C VI
San Francisco, *Fort Scott, B*	37 48.7 N	237 31	Feb 26, 21	10.8,12.7	18 05.1 E	....	....	11.3,12.2	.24694	26	....	C VI
			Do.	13.3,13.4,13.8	18 02.5 E	....	....	9.3,10.1	.24728	26	....	C VI
			Do.	14.0,14.5,14.7	18 01.9 E	....	....	10.9,11.7	.24715	26	....	C VI
			Do.	15.1,15.3	18 02.2 E	....	....	....	......	5	....	C VI
			Do.	15.6,15.8	18 02.6 E	....	....	....	......	5	....	C VI
			Mar 1, 21	13.0,13.2	18 03.4 E	....	....	9.1,10.0	.24732	5	....	C VI
			Do.	13.5,13.7	18 03.4 E	....	....	10.8,11.5	.24730	5	....	C VI
			Do.	....	....	....	....	14.1,14.8	.24724	5	....	C VI
			Mar 2, 21	....	....	9.4 to 13.3 (10)	62 19.1 N	....	......	....	EI 26	C VI
			Do.	....	....	13.9 to 15.2 (6)	62 18.7 N	....	......	....	EI 26	C VI
			Mar 3, 21	13.4,13.6,14.0	18 03.9 E	....	....	9.5,10.6	.24716	25	....	C VI
			Do.	14.3,14.7,14.8	18 03.1 E	....	....	11.3,12.9	.24710	25	....	C VI
			Do.	15.4 15.6	18 03.5 E	....	....	....	......	25	....	C VI
			Mar 4, 21	....	....	....	....	10.0,11.8	.24724	25	....	C VI
			Mar 10, 21	....	....	10.4 to 16.0 (14)	62 20.0 N	....	......	....	EI 25	C VI
			Mar 11, 21	....	....	9.2 to 14.4 (9)	62 18.5 N	12.9,13.8	.24736	5	EI 25	C VI
			Mar 14, 21	15.1 to 17.6 (dv)	18 02.7 E	....	....	....	......	5	....	C VI
			Mar 16, 21	7.9 to 9.4 (dv)	18 06.9 E	....	....	....	......	5	....	C VI
			Do.	15.0 to 17.6 (dv)	18 04.3 E	....	....	....	......	5	....	C VI
			Mar 17, 21	7.3 to 9.3 (dv)	18 18.1 E	....	....	....	......	5	....	C VI

SOUTH AMERICA.

ARGENTINA.

Station	Latitude	Long. East of Gr.	Date	Declination: Local mean time	Declination: Value	Inclination: L. M. T.	Inclination: Value	Hor. Intensity: L. M. T.	Hor. Intensity: Value	Instruments: Mag'r	Instruments: Dip circle	Obs'r
	° ′	° ′		h h h	° ′	h h	° ′	h h	c. g. s.			
Pilar, *B*	31 40.1 S	296 07	Mar 19, '17	8.9,11.2,11.9	8 15.3 E	....	....	9.5,10.6	0.25474	25	....	C IV
			Do.	16.0,16.5	8 16.3 E	....	....	14.2,15.3	.25476	25	....	C IV
			Mar 20, 17	8.9,11.7	8 11.4 E	....	....	9.5,11.0	.25486	25	....	C IV
			Mar 26, 17	....	....	10.9 (7)	25 36.7 S	....	....	....	EI 25	C IV
			Mar 27, 17	....	....	8.9 (3)	25 42.3 S	....	....	....	EI 25	C IV
			Apr 3, 17	8.9, 9.2	8 10.0 E	....	....	....	....	5	....	C IV
			Do.	14.4 to 16.5 (6)	8 16.6 E	....	....	....	....	5	....	C IV
Pilar, *Pier 4*	31 40.1 S	296 07	Mar 27, 17	....	....	10.5 to 12.6 (9)	25 37.4 S	....	....	....	EI 25	C IV
			Nov 10, 17	....	....	8.5, 8.8	25 38.5 S	....	....	....	EI 25	C V
			Do.	....	....	9.9 (4)	25 35.5 S	....	....	....	EI 25	C V
			Nov 13, 17	....	....	9.5, 9.8	25 36.8 S	....	....	....	EI 25	C V
			Do.	....	....	11.0 (4)	25 37.1 S	....	....	....	EI 25	C V
Pilar, *Pier 5*	31 40.1 S	296 07	Mar 20, 17	14.1,17.0	8 17.4 E	....	....	14.8,16.0	.25486	25	....	C IV
			Mar 21, 17	8.8,11.8,13.9	8 14.6 E	....	....	9.4,11.0	.25471	25	....	C IV
			Do.	....	....	....	....	14.5,15.6	.25460	25	....	C IV
			Apr 4, 17	9.0 to 11.6 (6)	8 12.7 E	....	....	....	....	5	....	C IV
			Nov 9, 17	10.6,10.9,11.4	8 12.3 E	....	....	8.8 to		25	....	C V
			Do.	13.6,15.2,17.2	8 10.6 E	....	....	16.8 (6)	.25482	25	....	C V
			Nov 12, 17	8.2,10.2,10.6	8 09.0 E	....	....	8.7 to		25	....	C V
			Do.	12.8,14.4,16.3	8 13.4 E	....	....	15 9 (6)	.25431	25	....	C V
Pilar, *E*	31 40.1 S	296 07	Mar 13, 17	9.7,15.0,15.9	8 16.2 E	....	....	10.8,14.5	.25434	25	....	C IV
			Mar 14, 17	8.8,11.5	8 14.4 E	....	....	9.4,11.0	.25442	25	....	C IV
			Do.	14.0,16.6	8 19.8 E	....	....	14.4,16.0	.25442	25	....	C IV
			Mar 15, 17	8.7,11.5,12.0	8 12.1 E	....	....	9.4,11.0	.25456	5	....	C IV
			Do.	14.0,16.5	8 17.4 E	....	....	14.6,16.0	.25444	5	....	C IV
			Mar 16, 17	8.7,11.3	8 10.7 E	....	....	9.2,10.8	.25465	5	....	C IV
			Do.	11.9	8 16.8 E	....	....	....	....	25	....	C IV
			Mar 22, 17	....	....	11.6,11.9	25 37.8 S	....	....	....	EI 3	C IV
			Do.	....	....	14.6,15.2	25 41.4 S	....	....	....	EI 3	C IV
			Do.	....	....	16.3 (4)	25 43.2 S	....	....	....	EI 3	C IV
			Mar 23, 17	....	....	9.5 (4)	25 41.2 S	....	....	....	EI 3	C IV
			Do.	....	....	11.3 (3)	25 38.0 S	....	....	....	EI 25	C IV
			Do.	....	....	14.9 (5)	25 41.5 S	....	....	....	EI 25	C IV
			Do.	....	....	16.4 (4)	25 43.6 S	....	....	....	EI 25	C IV
			Mar 27, 17	15.3 to 16.7 (4)	8 16.1 E	....	....	....	....	5	....	C IV
			Mar 28, 17	9.5 to 10.6 (4)	8 11.6 E	....	....	....	....	5	....	C IV
			Do.	11.1 to 14.3 (6)	8 18.0 E	....	....	....	....	25	....	C IV
			Oct 24, 17	15.1,17.5	8 13.8 E	....	....	15.7,17.0	.25416	5	....	C V
			Oct 25, 17	8.8,11.7	8 11.4 E	....	....	9.5,11.1	.25393	5	....	C V
			Do.	12.2,15.9	8 13.3 E	....	....	14.1,15.4	.25377	5	....	C V
			Oct 26, 17	9.3,12.1	8 09.1 E	....	....	10.0,11.4	.25428	25	....	C V
			Oct 27, 17	8.4,11.2	8 08.6 E	....	....	8.9,10.5	.25425	25	....	C V
			Oct 29, 17	8.6,11.1	8 10.8 E	....	....	9.3,10.7	.25398	25	....	C V
			Nov 1, 17	....	....	10.2 to 15.8 (12)	25 39.2 S	....	....	....	EI 3	C V
			Do.	....	....	16.9 (4)	25 43.2 S	....	....	....	EI 25	C V
			Nov 2, 17	....	....	15.4 (4)	25 41.2 S	....	....	....	EI 25	C V
			Do.	....	....	16.6 (4)	25 42.7 S	....	....	....	EI 25	C V
			Nov 5, 17	9.5 to 13.3 (dv)	8 10.7 E	....	....	....	....	25	....	C V
			Do.	14.6 to 17.6 (dv)	8 11.7 E	....	....	....	....	25	....	C V
Pilar, *F*	31 40.1 S	296 07	Mar 13, 17	9.7,15.0,15.9	8 16.3 E	....	....	10.8,14.5	.25410	5	....	C IV
			Mar 14, 17	8.8,11.5	8 13.2 E	....	....	9.4,11.0	.25452	5	....	C IV
			Do.	14.0,16.6	8 20.0 E	....	....	14.5,16.0	.25452	5	....	C IV
			Mar 15, 17	8.7,11.5,12.0	8 13.2 E	....	....	9.4,11.0	.25458	25	....	C IV
			Do.	14.0,16.5	8 19.3 E	....	....	14.6,16.0	.25447	25	....	C IV
			Mar 16, 17	8.7,11.3	8 12.1 E	....	....	9.2,10.8	.25470	25	....	C IV
			Do.	11.9	8 15.2 E	....	....	....	....	5	....	C IV
			Mar 17, 17	8.5 to 12.1 (dv)	8 12.3 E	....	....	....	....	25	....	C IV
			Do.	14.0 to 16.3 (dv)	8 18.3 E	....	....	....	....	25	....	C IV
			Mar 19, 17	17.0	8 14.4 E	....	....	9.3,11.1	.25452	5	....	C IV
			Do.	....	....	....	....	14.1,16.2	.25458	5	....	C IV
			Mar 20, 17	6.9 to 10.0 (dv)	8 09.9 E	....	....	....	....	5	....	C IV
			Mar 21, 17	6.4 to 9.1 (dv)	8 12.2 E	....	....	10.7,14.3	.25450	5	....	C IV
			Mar 22, 17	....	....	11.6,11.9	25 38.9 S	....	....	....	EI 25	C IV
			Do.	....	....	14.6,15.2	25 40.7 S	....	....	....	EI 25	C IV
			Do.	....	....	16.3 (4)	25 42.7 S	....	....	....	EI 25	C IV
			Mar 23, 17	....	....	9.5 (4)	25 40.9 S	....	....	....	EI 25	C IV
			Do.	....	....	11.3 (3)	25 39.0 S	....	....	....	EI 3	C IV
			Do.	....	....	14.9 (5)	25 42.8 S	....	....	....	EI 3	C IV
			Do.	....	....	16.4 (4)	25 44.5 S	....	....	....	EI 3	C IV
			Mar 26, 17	15.3 to 17.9 (dv)	8 16.4 E	....	....	....	....	25	....	C IV
			Mar 27, 17	15.3 to 16.7 (4)	8 17.1 E	....	....	....	....	25	....	C IV
			Mar 28, 17	9.5 to 10.6 (4)	8 11.8 E	....	....	....	....	25	....	C IV

SOUTH AMERICA.

ARGENTINA—*Concluded.*

Station	Latitude	Long. East of Gr.	Date	Declination: Local mean time	Declination: Value	Inclination: L. M. T.	Inclination: Value	Hor. Intensity: L. M. T.	Hor. Intensity: Value	Instruments: Mag'r	Instruments: Dip circle	Obs'r
	° ′	° ′		h h h	° ′	h h	° ′	h h	c. g. s.			
Pilar, *F*—*Concluded*	31 40.1 S	296 07	Mar 28, '17	11.1 to 14.3 (6)	8 18.7 E					5		C IV
			Mar 28, 17	15.0 to 16.1 (dv)	8 19.7 E					25		C IV
			Mar 29, 17			13.8,14.2	25 39.2 S	15.0	0.25457	25	EI 25	C IV
			Do.			16.0,16.3	25 42.6 S				EI 25	C IV
			Mar 30, 17			9.6 to 15.6 (8)	25 39.9 S	10.6,14.7	.25458	25	EI 25	C IV
			Apr 2, 17	8.9,10.6	8 12.0 E			9.4,10.2	.25436	5		C IV
			Do.	12.2,13.8	8 18.6 E			11.1,11.9	.25452	5		C IV
			Do.	15.2 to 17.7 (dv)	8 17.8 E					5		C IV
			Apr 3, 17			9.4 to 16.7 (5)	25 41.9 S	10.1	.25438	25	EI 25	C IV
			Do.					14.6,15.9	.25402	25		C IV
			Oct 24, 17	15.1,17.5	8 13.4 E			15.7,17.0	.25401	25		C V
			Oct 25, 17	8.8,11.7	8 11.0 E			9.4,11.1	.25376	25		C V
			Do.	12.2,15.9	8 12.8 E			14.1,15.4	.25386	25		C V
			Oct 26, 17	5.6 to 8.3 (dv)	8 07.3 E					25		C V
			Do.	9.3,12.1	8 09.8 E			10.0,11.5	.25422	5		C V
			Do.	15.3 to 18.3 (dv)	8 10.2 E					25		C V
			Oct 27, 17	8.4,11.2	8 09.7 E			9.0,10.5	.25432	5		C V
			Oct 29, 17	8.6,11.1	8 11.4 E			9.3,10.7	.25384	5		C V
			Do.					13.7 to 17.5 (6)	.25362	25		C V
			Oct 30, 17			12.1 (4)	25 38.6 S	9.0, 9.8	.25414	25	EI 25	C V
			Do.			16.9 (4)	25 45.2 S	14.9,15.8	.25385	25	EI 25	C V
			Oct 31, 17			8.4, 8.8	25 40.5 S	9.8,10.9	.25445	25	EI 25	C V
			Do.			12.7 (3)	25 35.2 S				EI 25	C V
			Nov 1, 17			10.2 to 15.8 (12)	25 39.1 S				EI 25	C V
			Do.			16.9 (4)	25 44.2 S				EI 3	C V
			Nov 2, 17			9.1, 9.6	25 40.0 S	10.6,10.9	.25470	25	EI 25	C V
			Do.			12.1 (3)	25 36.3 S				EI 25	C V
			Do.			15.4 (4)	25 41.6 S				EI 3	C V
			Do.			16.6 (4)	25 43.2 S				EI 3	C V
Florida, *A*	34 32.1 S	301 30	Feb 2, 20	10.9,13.8	4 39.8 E			11.6,13.4	.24578	5		C VI
			Do.	14.8,16.6	4 37.4 E			15.2,16.1	.24581	5		C VI
			Feb 3, 20	10.0,11.9	4 38.6 E			10.5,11.4	.24622	25		C VI
			Do.	13.4,14.8	4 40.3 E			13.8,14.5	.24633	25		C VI
			Do.	16.1 to 17.4 (dv)	4 39.2 E					25		C VI
			Feb 4, 20					10.2,10.7	.24616	5		C VI
			Feb 5, 20			10.8,11.1	27 50.2 S				EI 7	C VI
			Do.			11.6,11.9	27 50.2 S				EI 25	C VI
			Feb 9, 20	18.5	4 39.2 E					25		C VI
Florida, *B*	34 32.1 S	301 30	Feb 2, 20	10.9,13.8	4 38.9 E			11.6,13.4	.24586	25		C VI
			Do.	14.8,16.6	4 37.0 E			15.2,16.0	.24590	25		C VI
			Feb 3, 20	10.0,11.9	4 37.7 E			10.5,11.4	.24619	5		C VI
			Do.	13.4,14.8	4 39.5 E			13.8,14.5	.24628	5		C VI
			Feb 4, 20			13.2,13.8	27 54.4 S	10.2,10.7	.24620	25	EI 25	C VI
			Do.			15.6,15.9	27 55.6 S	14.5,15.0	.24606	25	EI 25	C VI
			Feb 5, 20			10.8,11.1	27 50.6 S				EI 25	C VI
			Do.			11.6,11.9	27 50.7 S				EI 7	C VI
			Do.			13.1,14.8	27 51.8 S	13.8,14.4	.24623	25	EI 25	C VI
			Feb 6, 20					10.0,11.1	.24621	25		C VI
			Do.					12.0,13.8	.24642	25		C VI
			Do.					14.5,15.8	.24638	25		C VI
			Feb 7, 20			10.0,11.3	27 52.3 S	10.7,11.8	.24602	25	EI 25	C VI
			Do.			11.5,12.3	27 51.2 S				EI 25	C VI

CHILE.

Station	Latitude	Long. East of Gr.	Date	Declination: Local mean time	Declination: Value	Inclination: L. M. T.	Inclination: Value	Hor. Intensity: L. M. T.	Hor. Intensity: Value	Instruments: Mag'r	Instruments: Dip circle	Obs'r
	° ′	° ′		h h h	° ′	h h	° ′	h h	c. g. s.			
Concepcion	36 49.6 S	286 57	Jan 16, '18	10.6,14.5	15 19.6 E	15.3,15.5	34 52.7 S	11.6, 14.1	0.26452	25	EI 25	C V
Coronel, *D*	37 01.9 S	286 51	Jan 19, 18	10.6,12.9,13.8	15 27.5 E	14.7,14.9	35 11.6 S	11.0, 12.4	.26484	25	EI 25	C V

PERU.

Station	Latitude	Long. East of Gr.	Date	Declination: Local mean time	Declination: Value	Inclination: L. M. T.	Inclination: Value	Hor. Intensity: L. M. T.	Hor. Intensity: Value	Instruments: Mag'r	Instruments: Dip circle	Obs'r
	° ′	° ′		h h h	° ′	h h	° ′	h h	c. g. s.			
Lima, *B*	12 04.3 S	282 58	Feb 28, '18	10.0,13.6	8 42.0 E			10.8,13.0	0.30113	5		C V
			Do.	14.0,17.3	8 41.4 E			14.6,16.7	.30068	5		C V
			Mar 1, 18	9.7,12.1	8 40.8 E			10.2,11.6	.30199	5		C V
			Do.	13.1,15.4	8 43.7 E			13.6,14.9	.30164	25		C V

SOUTH AMERICA.

PERU—*Concluded.*

Station	Latitude	Long. East of Gr.	Date	Declination: Local mean time	Declination: Value	Inclination: L. M. T.	Inclination: Value	Hor. Intensity: L. M. T.	Hor. Intensity: Value	Instruments: Mag'r	Instruments: Dip circle	Obs'r
	° ′	° ′		h h h	° ′	h h	° ′	h h	c. g. s.			
Lima, *B—Concluded*	12 04.3 S	282 58	Mar, 2, '18	8.0,10.1	8 39.4 E	....	....	8.4, 9.7	0.30134	25	....	C V
			Do.	10.6,12.7	8 45.1 E	....	....	11.1,12.8	.30284	25	....	C V
			Mar 5, 18	....	....	11.6 to 15.9 (12)	0 45.7 S	....	......	....	EI 25	C V
			Mar 6, 18	....	....	9.5 to 12.3 (12)	0 45.9 S	....	......	....	EI 3	C V
			Mar 7, 18	....	....	9.9 to 15.4 (9)	0 46.7 S	11.2,12.4	.30182	25	EI 25	C V
			Do.	....	....	....	....	13.7,14.2	.30162	25	....	C V
			Mar 11, 18	....	....	9.7 to 15.5 (10)	0 45.3 S	10.9,11.8	.30140	25	EI 25	C V
			Do.	....	....	....	....	13.9,14.3	.30070	25	....	C V
			Mar 13, 18	....	....	9.6 to 14.6 (10)	0 45.7 S	11.1,13.2	.30211	25	EI 25	C V
			Mar 14, 18	9.3, 9.6	8 40.0 E	....	....	....	......	5	....	C V
			Do.	10.2,10.6	8 40.6 E	....	....	....	......	5	....	C V
			Mar 18, 18	....	....	13.4 to 14.8 (8)	0 45.5 S	....	......	....	EI 25	C V
Lima, *C*	12 04.3 S	282 58	Feb 28, 18	10.0,13.6	8 42.3 E	....	....	10.8,13.0	.30124	25	....	C V
			Do.	14.0,17.3	8 41.8 E	....	....	14.6.16.7	.30076	25	....	C V
			Mar 1, 18	9.7,12.1	8 41.7 E	....	....	10.2,11.6	.30208	25	....	C V
			Do.	13.1,15.4	8 42.9 E	....	....	13.6,14.9	.30144	5	....	C V
			Mar 2, 18	8.0,10.1	8 38.9 E	....	....	8.4, 9.7	.30149	5	....	C V
			Do.	10.6,12.7	8 44.0 E	....	....	11.0,12.3	.30294	5	....	C V
			Mar 4, 18	9.4,11.0,13.2	8 41 9 E	....	....	9.8 to 16.0 (8)	.30180	25	....	C V
			Do.	14.8,16.4	8 44.6 E	....	....	....	......	25	....	C V
			Mar 5, 18	....	....	11.6 to 15.9 (12)	0 46.4 S	....	......	....	EI 3	C V
			Mar 6, 18	....	....	9.5 to 12.3 (12)	0 45.9 S	....	......	....	EI 25	C V
			Mar 9, 18	6.5 to 8.5 (dv)	8 39.3 E	....	....	....	......	25	....	C V
			Mar 12, 18	9.3 to 18.3 (dv)	8 42.0 E	....	....	....	......	25	....	C V
			Mar 14, 18	9.3, 9.6	8 40.5 E	....	....	....	......	25	....	C V
			Do.	10.2,10.6	8 42.0 E	....	....	....	......	25	....	C V
			Do.	12.3,12.5,12.6	8 44.5 E	....	....	....	......	25	....	C V
			Mar 15, 18	....	....	....	....	9.5 to 15.9 (8)	.30170	25	....	C V
			Mar 19, 18	....	....	....	....	9.6 to 16.2 (8)	.30187	25	....	C V

ISLANDS, ATLANTIC OCEAN.

ST. HELENA.

Station	Latitude	Long. East of Gr.	Date	Declination: Local mean time	Declination: Value	Inclination: L. M. T.	Inclination: Value	Hor. Intensity: L. M. T.	Hor. Intensity: Value	Instruments: Mag'r	Instruments: Dip circle	Obs'r
	° ′	° ′		h h h	° ′	h h	° ′	h h	c. g. s.			
Longwood, *A*	15 56.7 S	354 19	Mar 30, '20	10.8,13.9	25 07.2 W	15.4,15.7	38 20.8 S	11.5, 13.4	0.21736	25	EI 25	C VI

SOUTH GEORGIA.

Station	Latitude	Long. East of Gr.	Date	Declination: Local mean time	Declination: Value	Inclination: L. M. T.	Inclination: Value	Hor. Intensity: L. M. T.	Hor. Intensity: Value	Instruments: Mag'r	Instruments: Dip circle	Obs'r
	° ′	° ′		h h h	° ′	h h	° ′	h h	c. g. s.			
Edwards Point	54 18 S	323 34	Jan 13, '16	9.2,10.8	4 23.5 W	11.4,11.6	49 15.2 S	9.6, 10.4	0.24056	25	EI 25	C IV

ISLANDS, INDIAN OCEAN.

CEYLON.

Station	Latitude	Long. East of Gr.	Date	Declination: Local mean time	Declination: Value	Inclination: L. M. T.	Inclination: Value	Hor. Intensity: L. M. T.	Hor. Intensity: Value	Instruments: Mag'r	Instruments: Dip circle	Obs'r
	° ′	° ′		h h h	° ′	h h	° ′	h h	c. g. s.			
Colombo; *A*[1]	6 54.2 N	79 52	Jul 6, '20	8.6,12.0 12.4	2 29.5 W	....	....	9.3,11.5	0.38422	25	....	C VI
			Do.	....	....	....	....	13.0,14.3	.38392	25	....	C VI
			Do.	14.8,15.4,17.4	2 28.8 W	....	....	15.9,17.0	.38332	25	....	C VI
			Jul 7, 20	8.6, 9.8,10.3	2 28.2 W	....	....	....	......	25	....	C VI
			Do.	10.8,13.6	2 29.0 W	....	....	11.5,12.9	.38390	5	....	C VI
			Do.	14.8,17.0	2 28.9 W	....	....	15.8	.38344	5	....	C VI
			Jul 8, 20	10.1,11.7,12.2	2 29.2 W	....	....	9.3,10.5	.38406	5	....	C VI
			Do.	....	....	....	....	11.4	.38406	5	....	C VI
			Jul 12, 20	....	....	10.1 to 16.5 (10)	4 11.6 S	....	......	....	EI 25	C VI

[1]Local disturbance.

ISLANDS, INDIAN OCEAN.

CEYLON—*Concluded.*

Station	Latitude	Long. East of Gr.	Date	Declination: Local mean time	Declination: Value	Inclination: L. M. T.	Inclination: Value	Hor. Intensity: L. M. T.	Hor. Intensity: Value	Instruments: Mag'r	Instruments: Dip circle	Obs'r
	° '	° '		h h h	° '	h h	° '	h h	c. g. s.			
Colombo, *A*[1]—*Concluded*	6 54.2 N	79 52	Jul 13, '20			8.5 to 11.1 (7)	4 09.4 S				EI 7	C VI
			Jul 15, 20	15.4 to 17.1 (6)	2 27.8 W					25		C VI
			Jul 19, 20	8.8 to 10.2 (5)	2 28.2 W					25		C VI
Colombo, *C*[1]	6 54.2 N	79 52	Jul 6, 20	8.6,12.0,12.4	2 31.7 W			9.4,11.5	0.38435	5		C VI
			Do.					13.0,14.3	.38368	5		C VI
			Do.	14.8,15.4,17.4	2 29.3 W			15.9,17.0	.38340	5		C VI
			Jul 7, 20	8.6, 9.8,10.3	2 28.4 W					5		C VI
			Do.	10.8,13.6	2 29.8 W			11.4,12.9	.38426	25		C VI
			Do.	14.8,17.0	2 29.7 W			15.8	.38367	25		C VI
			Jul 8, 20	10.1,11.7,12.2	2 30.3 W			9.3,10.5	.38406	25		C VI
			Do.					11.4	.38416	25		C VI
			Do.					13.1,13.7	.38358	25		C VI
			Do.					14.7,15.8	.38339	25		C VI
			Jul 9, 20					8.4, 9.5	.38390	25		C VI
			Do.					10.2,11.3	.38410	25		C VI
			Do.	15.6 to 17.8 (dv)	2 29.5 W			12.6,13.3	.38400	25		C VI
			Jul 10, 20	6.6 to 8.7 (dv)	2 28.5 W					25		C VI
			Jul 12, 20			10.1 to 16.5 (10)	4 20.1 S				EI 7	C VI
			Jul 13, 20			8.6 to 11.1 (7)	4 17.3 S				EI 25	C VI
			Do.			14.4 to 16.6 (4)	4 20.5 S	15.2,15.8	.38370	25	EI 25	C VI
			Jul 14, 20	6.8 to 8.2 (dv)	2 28.0 W	9.4 to 16.7 (10)	4 19.3 S	10.3	.38422	25	EI 25	C VI
			Do.					15.7,16.3	.38351	25		C VI
			Jul 20, 20	16.2 to 18.0 (dv)	2 29.2 W					25		C VI

ISLANDS, PACIFIC OCEAN.

EASTER ISLAND.

Station	Latitude	Long. East of Gr.	Date	Declination: Local mean time	Declination: Value	Inclination: L. M. T.	Inclination: Value	Hor. Intensity: L. M. T.	Hor. Intensity: Value	Instruments: Mag'r	Instruments: Dip circle	Obs'r
	° '	° '		h h h	° '	h h	° '	h h	c. g. s.			
Cook Bay	27 08.0 S	250 35	Dec 27, '16	11.4,13.8	14 40.0 E	15.6,15.8	38 30.2 S	11.9,13.3	0.30762	25	EI 25	C IV
			Dec 29, 16	7.2 to								
			Dec 30, 16	7.7 (dv)	14 36.6 E					25		C IV

HAWAIIAN ISLANDS.

Station	Latitude	Long. East of Gr.	Date	Declination: Local mean time	Declination: Value	Inclination: L. M. T.	Inclination: Value	Hor. Intensity: L. M. T.	Hor. Intensity: Value	Instruments: Mag'r	Instruments: Dip circle	Obs'r
	° '	° '		h h h	° '	h h	° '	h h	c. g. s.			
Sisal, Honolulu Magnetic Observatory, *Pier A*	21 19.2 N	201 56	Jun 3, '15	9.9,12.0 13.9	9 41.1 E			10.4,11.6	0.29028	5		C IV
			Do.	16.0,16.5,18.6	9 41.4 E			14.4,15.6	.29029	5		C IV
			Do.					17.0,18.1	.29011	5		C IV
			Jun 4, 15	9.8,12.0,12.5	9 41.3 E			10.3,11.6	.29011	25		C IV
			Do.	16.3,16.8	9 40.6 E			14.8,15.8	.29022	25		C IV
			Do.					17.3	.29014	25		C IV
			Jun 5, 15	9.3, 9.5	9 43.4 E			8.8	.29025	25		C IV
			Do.	11.4,14.3	9 41.5 E			11.8,13.9	.29014	25		C IV
			Jun 21, 15			12.2 to 16.3 (6)	39 31.6 N				EI 25	C IV
			Do.			17.7 (4)	39 33.5 N				EI 25	C IV
			Jun 22, 15			13.7 to 17.9 (8)	39 31.5 N				EI 3	C IV
			Jun 23, 15			10.5 to		11.3,12.0	.28979	25		C IV
						17.1 (5)	39 31.4 N	15.4,16.4	.28984	25	EI 25	C IV
			Jun 24, 15			8.3 to		9.5,11.7	.29002	25		C IV
						16.9 (11)	39 29.5 N	14.0	.29017	25	EI 25	C IV
			Do.					15.4,16.0	.29014	25		C IV
			Jun 25, 15			9.1 to		9.6,11.1	.28987	25		C IV
						15.8 (10)	39 30.5 N	12.4	.28996	25	EI 25	C IV
			Jun 26, 15			9.0 (4)	39 30.2 N				EI 25	C IV
			Apr 18, 21					11.0,12.0	.28884	5		C VI
			Apr 18, 21					15.2,16.0	.28868	5		C VI
			Apr 19, 21	8.7 to 10.2 (6)	9 54.7 E			14.4,15.2	.28820	5		C VI
			Apr 21, 21			9.4 to 15.1 (6)	39 24.8 N				EI 25	C VI

[1]Local disturbance.

ISLANDS, PACIFIC OCEAN.

HAWAIIAN ISLANDS—*Concluded.*

Station	Latitude	Long. East of Gr.	Date	Declination: Local mean time	Declination: Value	Inclination: L. M. T.	Inclination: Value	Hor. Intensity: L. M. T.	Hor. Intensity: Value	Instruments: Mag'r	Instruments: Dip circle	Obs'r
	° ′	° ′		h h h	° ′	h h	° ′	h h	c. g. s.			
Sisal, Honolulu Magnetic Observatory, *Pier A—Concluded*	21 19.2 N	201 56	Apr 22, '21	....	....	9.4 (5)	39 25.4 N	....	......	....	EI 25	C VI
			Do.	....	....	10.0,11.6	39 25.2 N	10.4,11.0	0.28810	5	EI 25	C VI
			Apr 23, 21	....	....	9.7, 9.9	39 25.6 N	....	......	....	EI 25	C VI
			Do.	....	....	11.0,11.2	39 24.4 N	....	......	....	EI 25	C VI
Sisal, *A*	21 19.2 N	201 56	May 27, 15	10.4,13.0	9 41.0 E	....	....	11.0,12.5	.28992	25	....	C IV
			Do.	16.0,18.0	9 41.3 E	....	....	16.4,17.4	.28978	25	....	C IV
			May 28, 15	8.9,11.0	9 41.6 E	....	....	9.3,10.5	.28998	25	....	C IV
			Do.	11.5,14.7	9 39.0 E	....	....	11.9,14.3	.29009	25	....	C IV
			Jun 4, 15	9.8,12.0	9 41.7 E	....	....	10.3,11.6	.29002	5	....	C IV
			Do.	12.5,16.3,16.8	9 39.9 E	....	....	14.8,15.8	.29006	5	....	C IV
			Do.	....	....	....	....	17.3	.29013	5	....	C IV
			Jun 5, 15	9.3, 9.5	9 43.0 E	....	....	8.8,11.8	.29026	5	....	C IV
			Do.	....	....	....	....	13.9	.29012	5	....	C IV
			Jun 18, 15	....	....	13.9 to 17.6 (6)	39 34.4 N	....	......	....	EI 3	C IV
			Jun 19, 15	....	....	12.5 to 15.9 (6)	39 32.4 N	....	......	....	EI 25	C IV
			Do.	....	....	16.6	39 33.2 N	....	......	....	EI 3	C IV
			Jun 26, 15	....	....	10.3 to 14.3 (12)	39 31.1 N	....	......	....	EI 3	C IV
			Apr 15, 21	....	....	....	....	9.4,10.4	.28790	5	....	C VI
			Do	....	....	....	....	13.9,14.8	.28806	5	....	C VI
			Apr 20, 21	7.9, 8.1, 8.6	10 00.5 E	13.3 to				5	....	C VI
			Do	8.8, 9.2	9 59.8 E	17.2 (8)	39 28.0 N	....	......	5	EI 25	C VI
			Apr 21, 21	8.2	9 59.2 E	....	....	....	......	5	....	C VI
			Apr 25, 21	....	....	....	....	8.6, 9.5	.28832	5	....	C VI
			Do	....	....	....	....	15.0,15.9	.28808	5	....	C VI
Sisal, *B*	21 19.2 N	201 56	May 26, 15	16.4 to 18.6 (dv)	9 40.8 E	....	....	....	......	5	....	C IV
			May 27, 15	10.4,13.0	9 42.0 E	....	....	11.0,12.4	.29022	5	....	C IV
			Do	16.0,18.0	9 41.8 E	....	....	16,4,17.4	.29007	5	....	C IV
			May 28, 15	8.9,11.0	9 41.5 E	....	....	9.3,10.4	.29029	5	....	C IV
			Do	11.4,14.7	9 39.2 E	....	....	11.8,14.2	.29028	5	....	C IV
			May 29, 15	6.5 to 8.2 (dv)	9 46.0 E	....	....	10.4,11.1	.29033	5	....	C IV
			Do	10.0,11.7	9 42.3 E	....	....	12.1,12.7	.29032	5	....	C IV
			Do	13.2,14.3	9 37.6 E	....	....	14.6	.29032	5	....	C IV
			May 31, 15	8.6, 9.6,11.3	9 42.5 E	....	....	9.1 to		5	....	C IV
			Do	12.9,15.7,17.2	9 40.4 E	....	....	17.8 (9)	.29018	5	....	C IV
			Jun 1, 15	10.9,12.5,13.9	9 40.6 E	....	....	11.3 to		5	....	C IV
			Do	16.4,17.8	9 41.0 E	....	....	17.4 (8)	.29025	5	....	C IV
			Jun 2, 15	9.3,10.6	9 42.2 E	....	....	9.6, 10.3	.29040	5	....	C IV
			Do	12.0 to 16.3 (dv)	9 39.5 E	....	....	....	......	5	....	C IV
			Jun 3, 15	5.8 to 7.0 (dv)	9 43.5 E	....	....	10.4,11.6	.29030	25	....	C IV
			Do	9.9,12.0,13.9	9 41.2 E	....	....	14.4,15.5	.29030	25	....	C IV
			Do	16.0,16.5,18.6	9 41.7 E	....	....	17.0,18.2	.29022	25	....	C IV
			Jun 9, 15	....	....	....	....	15.7,17.3	.29017	25	....	C IV
			Jun 10, 15	10.0,11.7,12.0	9 42.5 E	....	....	10.4 to		5	....	C IV
			Do	14.2,15.9,17.4	9 41.2 E	....	....	17.1 (8)	.29040	5	....	C IV
			Jun 12, 15	15.0 to 18.6 (dv)	9 39.9 E	....	....	....	......	5	....	C IV
			Jun 14, 15	8.4,9.9,11.5	9 42.8 E	....	....	8.7 to		5	....	C IV
			Do	13.3,16.2,17.7	9 39.4 E	....	....	17.3 (10)	.29015	5	....	C IV
			Jun 15, 15	8.5,10.8	9 43.3 E	....	....	8.9 to		5	....	C IV
			Do	12.4,15.1	9 39.6 E	....	....	14.6 (6)	.29032	5	....	C IV
			Jun 16, 15	7.8 to 17.1 (dv)	9 40.5 E	....	....	....	......	25	....	C IV
			Jun 17, 15	7.6 to 8.7 (dv)	9 43.5 E	....	....	....	......	25	....	C IV
			Do	10.0 to 14.5 (dv)	9 37.4 E	....	....	....	......	5	....	C IV
			Do	14.8 to 17.5 (dv)	9 38.4 E	....	....	....	......	25	....	C IV
			Jun 22, 15	....	....	....	....	8.4, 9.3	.28972	25	....	C IV
			Jun 23, 15	6.1 to 8.2 (dv)	9 44.6 E	....	....	....	......	25	....	C IV

MARIANAS (LADRONE ISLANDS).

Station	Latitude	Long. East of Gr.	Date	Declination: Local mean time	Declination: Value	Inclination: L. M. T.	Inclination: Value	Hor. Intensity: L. M. T.	Hor. Intensity: Value	Instruments: Mag'r	Instruments: Dip circle	Obs'r
	° ′	° ′		h h h	° ′	h h	° ′	h h	c. g. s.			
Guam, Cabras Island	13 28 N	144 40	Aug 2, '16	9.3,10.6	2 00.0 E	11.5,11.7	14 03.6 N	9.7, 10.3	0.35042	25	EI 25	C IV
Guam, Orote Point	13 37 N	144 37	Jul 26, 16	10.0,11.3	1 56.8 E	12.5,12.9	14 05.4 N	10.4, 11.0	.34953	25	EI 25	C IV
Guam, Sumay, *A*	13 26.2 N	144 39	Jul 20, 16	10.5,13.2	1 58.8 E	....	....	11.0, 12.8	.34961	5	....	C IV
			Do	14.4,16.3	1 58.3 E	....	....	14.8, 15.9	.34924	5	....	C IV
			Jul 21, 16	8.9,11.0	1 59.9 E	....	....	9.4, 10.6	.34974	5	....	C IV
			Do	11.6,14.0	1 58.8 E	....	....	12.0, 13.7	.34982	25	....	C IV
			Do	14.5,16.2	1 58.4 E	....	....	14.9, 15.8	.34944	25	....	C IV
			Jul 22, 16	8.8,10.6	2.00.4 E	....	....	9.2, 10.2	.34977	25	....	C IV
			Jul 24, 16	....	....	11.3 (3)	14 04.3 N	....	......	....	EI 3	C IV
			Do	....	....	14.7 to 17.1 (6)	14 02.6 N	....	......	....	EI 3	C IV

ISLANDS, PACIFIC OCEAN.

MARIANAS (LADRONE ISLANDS)—*Concluded.*

Station	Latitude	Long. East of Gr.	Date	Declination: Local mean time	Declination: Value	Inclination: L. M. T.	Inclination: Value	Hor. Intensity: L. M. T.	Hor. Intensity: Value	Instruments: Mag'r	Instruments: Dip circle	Obs'r
	° ′	° ′		h h h	° ′	h h	° ′	h h	c. g. s.			
Guam, Sumay, *A*—*Concluded*	13 26.2 N	144 39	Jul 25, '16	....	....	11.4 (4)	14 01.9 N	....	......	....	EI 3	C IV
			Do.	....	....	14.0 to						
						16.3 (8)	14 02.2 N	....	......	....	EI 25	C IV
			Jul 28, 16	....	....	14.8 (4)	14 03.6 N	....	......	....	EI 25	C IV
Guam, Sumay, *B*	13 26.2 N	144 39	Jul 20, 16	10.5,13.2	1 58.6 E	....	....	11.0,12.8	0.34960	25	....	C IV
			Do.	14.4,16.3	1 56.8 E	....	....	14.8,15.9	.34944	25	....	C IV
			Jul 21, 16	8.9,11.0	2.00.7 E	....	....	9.4,10.6	.34968	25	....	C IV
			Do.	11.6,14.0	1 58.8 E	....	....	12.0,13.7	.34986	5	....	C IV
			Do.	14.5,16.2	1 59.0 E	....	....	14.9,15.9	.34952	5	....	C IV
			Jul 22, 16	8.8,10.6	2 01.1 E	....	....	9.2,10.2	.34956	5	....	C IV
			Jul 24, 16	....	....	10.8 to						
						17.1 (10)	14 03.2 N	....	......	....	EI 25	C IV
			Jul 25, 16	....	....	11.4 (4)	14 01.8 N	....	......	....	EI 25	C IV
			Do.	6.0 to 7.9 (dv)	2 03.5 E	14.0 to						
			Do.	9.4	2 02.2 E	16.3 (8)	14 02.0 N	....	......	25	EI 25	C IV
			Jul 26, 16	10.4,11.8	1 59.8 E	....	....	10.7 to		5	....	C IV
			Do.	14.2,15.9,17.1	2 00.9 E	....	....	16.8 (8)	.34928	5	....	C IV
			Jul 27, 16	....	....	9.4 to		10.4,11.5	.34952	25	....	C IV
						17.0 (6)	14 03.2 N	14.8,15.6	.34948	25	EI 25	C IV
			Jul 28, 16	....	....	8.8,10.4	14 03.0 N	9.3,10.0	.34970	25	EI 25	C IV
			Do.	....	....	10.9,12.3	14 02.6 N	11.4,12.0	.34962	25	EI 25	C IV
			Do.	....	....	14.8 (4)	14 03.4 N	....	......	....	EI 3	C IV
			Jul 29, 16	8.9 to 11.7 (dv)	1 58.9 E	....	....	....	......	25	....	C IV
			Jul 31, 16	9.2,10.6,11.9	1 57.5 E	....	....	9.5 to		25	....	C IV
			Do.	14.2,15.7	1 59.0 E	....	....	15.3 (8)	.34967	25	....	C IV
			Aug 3, 16	15.9 to 17.9 (dv)	2 01.1 E	....	....	....	......	5	....	C IV

SAMOAN ISLANDS.

Station	Latitude	Long. East of Gr.	Date	Declination: Local mean time	Declination: Value	Inclination: L. M. T.	Inclination: Value	Hor. Intensity: L. M. T.	Hor. Intensity: Value	Instruments: Mag'r	Instruments: Dip circle	Obs'r
	° ′	° ′		h h h	° ′	h h	° ′	h h	c. g. s.			
Apia, Samoa Observatory, *A*	13 48.4 S	188 14	Jul 1, '21	....	....	....	....	10.9,11.8	0.35264	5	....	C VI
			Do.	....	....	....	....	14.4,15.4	.35244	5	....	C VI
			Jul 2, 21	....	....	....	....	10.6,11.6	.35259	5	....	C VI
			Jul 5, 21	9.8 to 11.6 (6)	10 11.8 E	....	....	....	......	5	....	C VI
			Jul 12, 21	....	....	....	....	9.6,10.7	.35259	25	....	C VI
			Do.	....	....	....	....	11.7	.35243	25	....	C VI
			Jul 13, 21	....	....	....	....	7.8, 9.0	.35226	25	....	C VI
			Do.	....	....	....	....	10.1	.35236	25	....	C VI
			Do.	....	....	....	....	11.6,12.2	.35216	5	....	C VI
			Jul 13, 21	....	....	....	....	13.8	.35245	5	....	C VI
			Jul 16, 21	....	....	10.6,11.6	30 01.6 S	....	......	....	EI 25	C VI
			Jul 18, 21	10.0,10.1,10.9	10 12.1 E	14.4,14.8	30 00.8 S	....	......	25	EI 25	C VI
			Do.	11.1,11.6,12.5	10 12.5 E	15.4,15.8	30 01.4 S	....	......	25	EI 25	C VI
			Jul 19, 21	....	....	10.4 (3)	30 00.0 S	....	......	....	EI 25	C VI
			Jul 20, 21	....	....	9.5 to						
						12.0 (6)	29 59.9 S	....	......	....	EI 25	C VI
Apia, Samoa Observatory, *B*	13 48.4 S	188 14	Jul 1, 21	....	....	....	....	14.4,15.4	.35244	25	....	C VI
			Jul 2, 21	....	....	....	....	10.6,11.7	.35245	25	....	C VI
			Jul 5, 21	9.8 to 11.6 (6)	10 12.3 E	....	....	....	......	25	....	C VI
			Jul 11, 21	....	....	....	....	14.4,15.6	.35244	25	....	C VI
			Jul 12, 21	....	....	....	....	9.5,10.7	.35228	5	....	C VI
			Do.	....	....	....	....	11.7	.35226	5	....	C VI
			Jul 13, 21	....	....	....	....	7.7, 9.0	.35220	5	....	C VI
			Do.	....	....	....	....	10.1,....	.35226	5	....	C VI
			Jul 13, 21	....	....	....	....	12.2,13.8	.35222	25	....	C VI
			Jul 18, 21	10.0 to 11.8 (6)	10 12.5 E	....	....	....	......	5	....	C VI
			Jul 19, 21	....	....	11.8 to						
						15.0 (7)	30 02.8 S	....	......	....	EI 25	C VI
			Jul 20, 21	....	....	14.9 to						
						17.1 (6)	30 03.5 S	....	......	....	EI 7	C VI
Apia, Samoa Observatory, *N. Pier*	13 48.4 S	188 14	Jul 7, 21	....	....	....	....	14.0,14.9	.35278	5	....	C VI
			Jul 8, 21	....	....	....	....	9.8,10.8	.35248	5	....	C VI
			Do.	....	....	....	....	12.8,15.1	.35260	5	....	C VI
			Jul 9, 21	....	....	....	....	9.7,11.0	.35257	5	....	C VI
			Jul 11, 21	10.0 to 11.8 (6)	10 08.7 E	....	....	....	......	5	....	C VI
			Do.	....	....	....	....	14.3,15.6	.35258	5	....	C VI
			Jul 15, 21	10.2 to 11.7 (6)	10 09.0 E	....	....	....	......	5	....	C VI
Apia, Samoa Observatory, *S. E. Pier*	13 48.4 S	188 14	Jul 20, 21	....	....	14.9 to						
						17.1 (6)	30 04.2 S	....	......	....	EI 25	C VI
Apia, Samoa Observatory, *West Pier*[1]	13 48.4 S	188 14	Jul 6, 21	....	....	....	....	9.0 to				
								13.9 (5)	.35244	5	....	C VI

[1] *West Pier* was examined before these observations and was found to be magnetic. Hence these and all previous results obtained at West Pier are subject to question.

ISLANDS, PACIFIC OCEAN.

SAMOAN ISLANDS—*Concluded.*

Station	Latitude	Long. East of Gr.	Date	Declination: Local mean time	Declination: Value	Inclination: L. M. T.	Inclination: Value	Hor. Intensity: L. M. T.	Hor. Intensity: Value	Instruments: Mag'r	Instruments: Dip circle	Obs'r
	° ′	° ′		h h h	° ′	h h	° ′	h h	c. g. s.			
Apia, Samoa Observatory, *West Pier*[1]—*Concluded*	13 48.4 S	188 14	Jul 7, '21	....	....	....	....	9.8,10.1	0.35214	5	....	C VI
			Do.	....	....	....	....	14.0	.35221	25	....	C VI
			Jul 8, 21	....	....	....	....	9.8,10.8	.35206	25	....	C VI
			Do.	....	....	....	....	12.8,15.1	.35212	25	....	C VI
			Jul 11, 21	10.0 to 11.8 (6)	10 09.0 E	....	....	....	......	25	....	C VI
			Jul 15, 21	8.1 to 9.3 (6)	10 10.0 E	....	....	....	......	5	....	C VI
Pago Pago[2]	14 16.8 S	189 20	Jun 12, 16	....	....	15.1 (3)	29 46.4 S	....	......	....	EI 25	C VI
			Jun 13, 16	10.3,12.3	9 27.8 E	....	....	10.8,11.9	.35670	25	....	C IV
			Jun 16, 16	10.8,11.1	9 28.6 E	....	....	....	......	25	....	C IV

SOCIETY ISLANDS.

Station	Latitude	Long. East of Gr.	Date	Declination: Local mean time	Declination: Value	Inclination: L. M. T.	Inclination: Value	Hor. Intensity: L. M. T.	Hor. Intensity: Value	Instruments: Mag'r	Instruments: Dip circle	Obs'r
	° ′	° ′		h h h	° ′	h h	° ′	h h	c. g. s.			
Point Fareute[2]	17 31.5 S	210 26	Dec 27, '20	11.5,11.7	10 11.2 E	13.0,14.1	30 58.0 S	13.4,14.7	0.32432	25	EI 25	C VI
			Do.	....	....	15.1	30 59.1 S	....	......	....	EI 25	C VI

[1] *West Pier* was examined before these observations and was found to be magnetic. Hence these and all previous results obtained at West Pier are subject to question. [2] Local disturbance.

DISTRIBUTION OF SHORE STATIONS, 1905–1921.

The following summary shows the geographical distribution of the shore stations occupied by the *Galilee* parties during cruises 1, 2, and 3, and by the *Carnegie* parties during cruises I, II, III, IV, V, and VI, covering the total period of the ocean work, 1905–1921, as published in Volume III and in the present volume. At each port of call where intercomparisons of ship instruments and the standard land instruments were undertaken, two or more stations were established; these are listed as separate stations in the summary. Of the grand total of 234 occupations listed in the summary, 191 are new stations and 43 are reoccupations. Many of these stations have been reoccupied also by the Department's land expeditions, and the results will be found published in Volumes I, II, and IV. The secular-variation data thus obtained, together with the information resulting from *Galilee* and *Carnegie* cruise intersections, will be utilized in a later discussion of the time-variations in the Earth's magnetic field.

Summary showing Geographical Distribution of Galilee and Carnegie Shore Stations, 1905–1921.

Countries and islands	*Galilee* cruise			*Carnegie* cruise					
	1	2	3	I	II	III	IV	V	VI
	1905	1906	1907–1908	1909–1910	1910–1913	1914	1915–1917	1917–1918	1919–1921
British South Africa					4				2
China and Japan		3	4						
Australia and New Zealand			5				4		10
Great Britain and Norway				4	7	7			
United States and Central America	8	4	5	3	3	2	8	2	5
Argentina, Brazil, Chile, and Peru			2		17		5	8	2
Iceland, Bermudas, Madeiras, and West Indies				8	4	9			
St. Helena, Falkland, and South Georgia					7		1		1
Ceylon, Java, and Mauritius					14				2
Caroline, Marshall, Fiji, and Samoan Islands		8	7		2		1		5
Hawaiian, Marianas, and Philippine Islands	1	4	3		3		7		2
Fanning, Marquesas, Easter, and Society Islands	1	2	13		3		1		1
Totals	10	21	39	15	64	18	27	10	30

DESCRIPTIONS OF SHORE STATIONS, 1915–1921.

As stated in the previous volumes, one of the chief difficulties experienced by the observers of the Department of Terrestrial Magnetism in the reoccupation of old stations for secular-variation data has been the lack of information necessary to precise recovery of the point where the previous observations were made. Owing to the frequent occurrence of local disturbances, it may readily happen that erroneous secular-variation data will result from non-recovery of exact station. Accordingly the observers of the Department are instructed to furnish as complete descriptions as possible of stations occupied, especially of such as give promise of future availability. Information additional to that contained in the published descriptions or copies of station-sketches or of photographs of surroundings will gladly be supplied to those interested in the reoccupation of any of the stations.

The descriptions are given in alphabetical order under the same geographical divisions adopted in the preceding Table of Shore Results. The general form followed in the descriptions is: Name of station, year when occupied, general location, detailed location, distances and references to surrounding objects, manner of marking, and finally the true bearings of prominent objects likely to be of permanent character. All bearings, unless specifically stated otherwise, are true ones, and are reckoned continuously from 0° to 360°, in the direction south, west, north, east. When no mention is made of marking of station, it is to be understood that the station was either not marked at all or not in a permanent manner.

Most of the measured distances were made originally in the English system; however, the distances obtained by conversion into the metric system are also given, but inclosed in parentheses, so as to show that they are converted figures. The following rules have been adopted in the conversions: Distances given to 01.0 foot are converted to the nearest 0.001 meter, 0.1 foot to the nearest 0.01 meter, 1 foot to the nearest 0.1 meter, estimated feet or yards to nearest meter, estimated fraction of a mile to nearest 0.1 kilometer, and estimations of more than a mile to nearest kilometer. Short and important reference distances, when measured accurately, have been converted into nearest 0.1 centimeter; such measurements, however, as, for example, dimensions of marking-stones, etc., which are not of great importance, have been converted to the nearest centimeter. If a distance is given immediately preceding an azimuth of a mark, it is to be interpreted as distance from the magnetic station to the mark.

AFRICA.

BRITISH SOUTH AND CENTRAL AFRICA.

Cape Town, Cape Colony, 1920.—Close reoccupation of C. I. W. stations of 1911, in field belonging to Valkenberg Mental Hospital, back of North Lodge and bounded on north and west by grounds of Royal Astronomical Observatory. Station *A* is 83.2 meters east of fence along east side of avenue leading to hospital, and 83.2 meters north of fence along south side of field. True bearings: middle spire of three on church, 26° 58′.9; tall spire with weathercock, 99° 37′.1; east gable of hospital lodge, 124° 31′.7; top of lower part of observatory flagpole, 157° 43′.7; base of flagpole on windmill, 212° 58′.2; bottom of weather-vane on hospital tower, 317° 44′.9.

Station *C* is 29.78 meters northwest of station *A* in line through station *A* to bottom of weather-vane on hospital tower; it is 71 meters from the southeast corner of hospital lodge lot, which bears 139°, and 93.7 meters from southwest corner, which bears 115°, and 70.0 meters nearly east of iron fence-post, which is 60.9 meters south of southwest corner of lodge lot. True bearings: center spire of three on church, 25° 38′.7; east gable of hospital lodge, 125° 17′.0; bottom of weather-vane on hospital tower, 317° 44′.9.

AUSTRALASIA.

AUSTRALIA.

Cottesloe, Western Australia, 1920.—For the purpose of making intercomparisons of instruments, C. I. W. stations *A* and *B* of 1914 were exactly reoccupied, in the Government Educational Endowment Reserve, in Osborne District, Cottesloe, near Perth, northeast of junction of Grant street and Marmion street. Station *A* is 240.5 feet (73.30 meters) northeast of sign-post at southwest corner of reserve, and 160.2 feet (48.83 meters) north of telegraph-pole in north edge of Grant street; marked by a jarrah post 1.5 by 2.5 inches (4 by 6 cm.) sunk slightly below surface of ground. True bearings: bottom of left end of fence by quarry, three-fourths mile (1.2 km.), 20° 14′.3; top of sign-post at corner Grant and Marmion streets, 51° 34′.9; near gable of house on hill, 52° 34′.6; spike on front gable of house, one-third mile (0.5 km), 120° 40′.7; ornament on left gable of Methodist church, one mile (1.6 km.), 205° 17′.7; ornament on roof of near house, 263° 12′.4.

Station *B* was established on the line from the left end of fence by quarry through station *A*, being 110 feet (33.5 meters) north-northeast of station *A*.

Watheroo Observatory, 1920.—The stations regularly used for control of variometers, piers N_m and N_w in absolute observatory, the former being the central of three piers at north end of building and the latter the pier in northwest corner of building, and piers S_m and S_w in absolute observatory, the former being the central of three piers at the south end of building and the latter the pier in southwest corner of building, were all used in the intercomparisons of the *Carnegie* standard land instruments with the Watheroo Observatory standards. The mark used for declination work at N_m is center of two black lines on board 947.6 feet (288.83 meters) distant in true bearing 265° 06′.6 west of south. The mark used for declination work at S_m is the same as for N_m and distant 951.6 feet (290.05 meters) in true bearing 263° 35′.9.

NEW ZEALAND.

Christchurch, South Island, 1915, 1916, 1920.—Observations were made on East Pier and West Pier of absolute house of Christchurch Observatory, and at stations designated Jarrah Peg and Brass Pipe. Jarrah Peg is station "peg A" of 1907–8, and is 12.14 meters north of northeast corner of absolute house and 14.10 meters northeast of northwest corner. True bearings: iron pipe, RM_1, 196° 03′.8; iron pipe 2, 200° 13′.3. Brass Pipe is identical with station of that name occupied in 1907–8, 21.70 meters northeast of Jarrah Peg. True bearing: iron pipe 2, 195° 14′.2.

NORTH AMERICA.

CENTRAL AMERICA.

Colon, Sweetwater, Panama, 1915.—About 2.5 miles (4 km.) due west of Cristobal Channel, on north side of Sweetwater Bay, approximately one-fourth mile (0.4 km.) southwest of station of 1907, 1908, 1909, and 1912, and approximately 100 meters west-southwest of station *B* of 1912, on a low sandy stretch of beach from which line of vision to Colon passes near a shelf of rock on right shore, called by natives "Pelo Bendito," and at right angles to telephone-lines across bay. Station *A* is about 2 meters from water's edge; marked by wooden peg. True bearings: left edge entrance to bay, 226° 19′; left edge Washington Hotel, 247° 13′.8; left wireless tower, 250° 51′.8; right wireless tower, 251° 43′.1; right entrance to bay, 253° 45′.

Station *B* is 61.25 meters north of station *A*, about 14 meters from water's edge, 7 meters southeast of a palm, and in direction of *A* are some stumps that were the foundation of a native hut; marked by wooden peg. True bearings: left edge Washington Hotel, 247° 30′.8; center left wireless tower, 251° 06′.2; center right wireless tower, 251° 57′.1.

Colon, Sweetwater, Panama, C, 1921.—About 2.5 miles (4 km.) due west of Cristobal Channel, on north side of Sweetwater Bay, near stations *A* and *B*, of 1915. These stations could not be reoccupied, as an 8-inch iron pipe-line has been laid close to their positions.

Station *C*, so designated to distinguish it from *A* and *B* of 1915, is about 6 feet from high-water line, 69.5 feet (21.2 meters) from iron pipe No. 4505, to northwest, and 78.2 feet (24.4 meters) from iron pipe No. 2170 to southwest. It is near a group of three palms forming an equilateral triangle, whose sides are approximately 20 feet (6.1 meters) long. It is 11.6 feet (3.5 meters) from the east tree of this group and 27.3 feet (8.3 meters) from the north one.

Pipe section No. 698, the one immediately south of No. 2170, is the 31st section counting from the large valve in the line near the wooden foot-bridge across the mouth of Sweetwater River.

The exact spot was not marked, but the three brass-bound tripod pegs were left in the ground. These pegs are about 10 inches long, and are driven flush with the ground. True bearings: south end of bridge at water-line, 6° 20′. Galeta Point, 231° 02′.9; tip of left wireless mast, 251° 26′.6; pilot's signal tower behind pier 6, 261° 25′.3.

Colon, Washington Hotel, Panama, 1915.—The station is east of hotel grounds in Bolivar Street near where it ends at sea-wall, and north-northwest of Christ Episcopal Church, 8.97 meters east of eastern wall of hotel grounds at fourth pillar, 20.70 meters southeast of pillar at junction of hotel wall and sea-wall, 23.93 meters southwest of pillar at end of sea-wall, and 41.43 meters northwest of lamp-post at nearest corner of church; marked by large wooden stake. True bearings: signal-pole on top of Washington Hotel, 33° 12′; light on east end of west breakwater, 145° 08′.9; east end of east breakwater, 205° 06′; lamp-post at corner of Christ Episcopal Church, 325° 21′.

NORTH AMERICA.

CENTRAL AMERICA—*continued.*

Cristobal, Canal Zone, 1918.—About 1 kilometer east of coaling-station, on main road Colon to Gatun, near quartermaster's garage, about 225 meters directly behind the middle one of three houses numbered 6001, 6003, and 6005, and about 125 meters south-southeast of a small round knoll covered with palms. Two stations were occupied, station *B* being 30.9 meters east by south from station *A*. Not suitable for reoccupation.

Old Panama, Panama, 1921.—The station is located on the site of the ruins of the old city of Panama, about 8 miles east of Ancon. It is 72.5 feet (22.1 meters) west of the southern corner of the ruined square cathedral tower, the most prominent ruins in old Panama, and is in line with that face of the tower which is toward the sea. Marked by a 10-inch brass-bound tripod peg driven flush with the ground. True bearings: extreme east end of Taboguilla Island, 6° 36′.3; gable of house on Culebra Island, almost in line with coconut palm on the beach, 23° 46′.2; gable of building to west, 62° 32′.6; southwest corner of old cathedral tower, 258° 36′.3

UNITED STATES.

Dutch Harbor, Alaska, 1915.—On Amaknak Island, on medium high ground north of village of Dutch Harbor, north of Unalaska and U. S. Navy wireless stations, about 300 yards (274 meters) northwest of pier extending eastward into harbor at about middle of village, in line with wireless station and large white house in Unalaska known as Jesse Lee Home, and in line with edge of bay near pier and a grass-covered water-tank on knoll; station *A* is marked by 10-inch post projecting about 1 foot (30 cm.) and having on its top a circular brass plate inscribed C. I. W. 1915 with a small drill-hole to mark exact spot. True bearings: peak east of Captains Bay, 12° 44′.5; upper knob of volcano slope, 131° 15′.5; beacon on spit, 252° 50′.4; pole on C. and G. S. station near water-tank, 328° 54′.2; center gable of Jesse Lee Home, 344° 24′.4.

Station *B* is 34.2 meters north of *A* in line from center gable of Jesse Lee Home extended through station *A*. True bearings: upper knob of volcano slope, 131° 10′.4; beacon on spit, 254° 04′.7; pole over C. and G. S. station, 329° 47′.4; center gable of Jesse Lee Home, 344° 24′.4; west gable of Jesse Lee Home, 344° 45′.0.

The *C. and G. S.* station of 1913 was reoccupied. On Amaknak Island southeast of village near crown of hill, about 164 feet (50 meters) south of sod-covered water-tank, 98 feet (30 meters) south of observatory azimuth mark; marked by square dressed stone with a drill-hole in top. True bearings: point on mountain, 76° 44′.0; observatory azimuth mark, 180° 00′.3; white post near end of island, 341° 17′.8.

Goat Island, California, 1916.—Station *A* is reoccupation of U. S. Coast and Geodetic Survey station of 1904 and C. I. W. station of 1905 and 1908, on military reservation, near center of small plateau on western slope of hill at eastern end of island, slightly south of line from top of hill to smokestack at naval training-station, and 48 feet (14.6 meters) north of line of two flagpoles, one on highest point of island and other on southern part of lawn at officers' quarters; marked by a rough stone about 6 inches (15 cm.) square with a hole in top. True bearings: tip of east radio mast, 44° 58′.7; tip of west radio mast, 62° 17′.6; right edge of chimney of house No. 8, 74° 02′.4; lighthouse on McDowell Point, 85° 56′.2; tip of lighthouse on Alcatraz Island, 104° 03′.4; campanile at University of California, 234° 36′.7; center of gable at Western Pacific ferry, 300° 07′.1.

Station *B* is 64 meters west of *A* in line from station to lighthouse on McDowell Point. True bearings: top of east radio mast, 43° 47′.7; lighthouse on McDowell Point, 85° 56′.2; lighthouse on Alcatraz Island, 104° 07′.7; campanile, 234° 40′.2; center of gable on Western Pacific ferry, 299° 55′.0.

San Francisco, Fort Scott, 1921.—Two stations were occupied in the military reservation of Fort Scott.

Station *A* is located in the vacant plot of ground north of the parade ground, about 415 feet (126 meters) south of large barracks building; marked by a pine post 1.5 by 24 inches (4 by 61 cm.) True bearings: base of flagpole in front of Fort Scott headquarters, 7° 04′.7; light on Point Stewart, west end of Angel Island, 201° 20′.1; lighthouse on Alcatraz Island, 242° 30′.0.

Station *B* is 86.8 feet (28.6 meters) northeast of *A* and in line with lighthouse on Alcatraz Island. It is in line with the northwest side of the fourth (from the lower side of the hill) house which faces the beach road and is about 800 feet (244 meters) distant; marked by a hole in the top of a granite post 6 by 6 by 18 inches (15 by 15 by 46 cm.), with the letters "C. I. W. 1921" cut in the top surface. True bearings: base of flagpole in front of Fort Scott headquarters, 9° 27′.0; lighthouse on Lime Point, 169° 38′.5; light on Point Stewart, west end of Angel Island, 201° 11′.6.

San Rafael, California, 1921.—Exact reoccupation of U. S. Coast and Geodetic Survey station of 1897 and C. I. W. stations of 1905, 1908, and 1916, 1.1 miles (1.8 km.) west-northwest of county court-house, on eastern slope of hill about 375 feet (114 meters) east of water company's reservoir; marked by marble post 8 by 8 by 48 inches (20 by 20 by 122 cm.) projecting about 24 inches (61 cm.) above surface of ground, and lettered U. S. C. and G. S. on its west vertical face, MAG. STA. on its south face, and 1897 on its east face, with a cross on the upper face marking exact point. True bearings: meteorological station on Mount Tamalpais, 26° 58′.4; flagpole on county court-house, 289° 46′.3.

SOUTH AMERICA.

ARGENTINA.

Florida, Buenos Aires, 1920.—Two stations were occupied. Station *A* is in vacant plot of ground 6 blocks west of Florida railway station within square bounded on north by Calle Llavallol and on west by Calle Blas Parera, 308 feet (93.9 meters) south of near side of former, and 260 feet (79.2 meters) east of far side of latter; marked by wooden peg. True bearings: minaret nearest flagstaff on residence, 8° 29′.0; spire on residence, 73° 59′.9; ventilator on distant house, 190° 41′.0; spire on church, 256° 35′.4.

Station *B* is 100 feet (30.5 meters) nearly north of *A* in line with ventilator on distant house; marked by wooden peg. True bearings: minaret nearest flagstaff, 8° 44′.4; spire on Sr. Wiggin's house, 76° 01′.7; ventilator on distant house, 190° 41′.0; spire on church, 256° 59′.1.

Pilar, Cordoba, 1917.—On grounds of Pilar Observatory of Argentine Meteorological Office. Station *B* is an exact reoccupation of the C. I. W. station *B* of 1911, a wooden pier having been set and a small frame building erected over the spot. Declination and horizontal intensity were observed at *Pier 4*, and inclination on *Pier 5* in the new absolute observatory called station *D*. For intercomparison of instru-

SOUTH AMERICA.

ARGENTINA—*continued.*

ments two stations, *E* and *F*, were established in line from *Pier 4* at station *D* to left edge of a house about 2 kilometers distant in azimuth 119° 20′.6. Station *E* is 71.26 meters west of northwest corner of variation observatory, 89.54 meters northeast of stone pier used as observatory azimuth mark, 73.35 meters east of east corner of observers' quarters, and 87.48 meters southwest of south corner of carpenter shop. Station *F* is 26.30 meters northwest of *E* in line toward their common azimuth mark, the left edge of house distant about 2 kilometers, whose bearing is 119° 20′.6.

CHILE.

Concepcion, Concepcion, 1918.—Practical reoccupation of C. I. W. station of 1913. In low pasture land on east side of grounds of agricultural college, 32.6 meters south of wire fence along main road near entrance to school grounds, 33.7 meters west of fence along road to east, and 17.8 meters northeast of near corner of small bridge. True bearings: near corner of small bridge, 48° 22′.1; right-hand vase-like ornament on distant house, 91° 10′.1; post at northeast corner of inclosure, 240° 05′.1; telephone-pole on hill-slope, 270° 09′.2.

Coronel, Concepcion, 1918.—The station is on a sandy plain about 1 kilometer southeast of town and is about 80 meters south-southeast of U. S. Coast and Geodetic Survey station of 1907 and C. I. W. stations of 1912 and 1913, which were found unsuitable for reoccupation, on southeast end of highest and most easterly one of a group of sandy knolls, about 200 meters northwest of slaughter-house. True bearings: middle corner of middle house on hill above Lota, 19° 36′.1; west edge cornice at top of soap-factory chimney, 155° 04′.0; brick chimney east of town, 201° 47′.9; north gable of slaughter-house, 320° 17′.7.

PERU.

Lima, Lima, 1918.—As station *Hipodromo* of 1914, 1916, and 1917 could not be recovered, stations *B* and *C* were established.

Station *B* is about 70 meters west-southwest of station *Hipodromo*, 108.5 meters northeast of east corner of brick foundation under bay window on southeast side of middle one of three hexagonal buildings within race-course, 1.7 meters southwest of extension of northeast face of small building southwest of grand-stand and 119.5 meters southeast of east corner of its brick foundation. True bearings: point on left end of distant house, 59° 44′.9; cross on church dome, 127° 11′.0; right corner of foundation of small building near grand-stand, 158° 55′.9; wireless tower on San Cristobal Hill, 215° 10′.5; right corner of railing on roof of house outside grounds, 342° 16′.0.

Station *C* is 49 meters southwest of station *B* in line with point on left end of distant house. True bearings: point on left end of distant house, 1,300 meters, 59° 44′.9; cross on church dome, 129° 59′.8; right corner of foundation of small building near grand-stand, 173° 07′.0; wireless tower on San Cristobal Hill, 215° 20′.7.

ISLANDS, ATLANTIC OCEAN.

ST. HELENA.

Longwood, A, 1920.—Exact reoccupation of C. I. W. station of 1913. On lawn in front of house in which Napoleon died, 53.05 meters west-southwest of southwest corner of north post of gate, 34.1 meters northwest of west corner of masonry support for

ISLANDS, ATLANTIC OCEAN.

ST. HELENA—*continued.*

three water-tanks, and 13.1 meters due south of point in line with flax hedge; post marking site had decayed and point was further marked by oak stake bound around top with brass ferrule. True bearings: west edge of door-way in single house across valley, 3° 05′.6; flagstaff at High Knoll Fort, 102° 30′.4.

SOUTH GEORGIA.

Edwards Point, King Edward Cove, 1916.—On southeast side of Edwards Point, about 6 feet (2 meters) above water, on flat piece of ground, about 30 to 50 feet (9 to 15 meters) wide, bordering sloping beach between Edwards Point Light and English magistrate's office, at a point between path and beach about 90 paces from light and about 1 pace southeast of line from light to magistrate's flagpole; marked by 3-inch stub projecting about 4 inches (10 cm.) above ground, with brass screw marking center. True bearings: south one of two ranges, prominent squared and painted poles, set by Captain Shackelton for convenience of vessels testing their compasses, 40° 35′.0; north range, 43° 41′.5; Edwards Point Light, 71° 06′.4; spire of Lutheran church, 112° 32′.2; base British flagstaff, 250° 01′.7.

ISLANDS, INDIAN OCEAN.

CEYLON.

Colombo, 1920.—C. I. W. Stations *A* and *C* of 1911 were reoccupied, in western part of grounds of Colombo Observatory, in Cinnamon Gardens off Buller's Road. Station *A* is 108 feet (32.9 meters) southwest of fence, 164 feet (50.0 meters) southwest of southwest corner of office building, and 80.6 feet (24.57 meters) west of thermometer shelter; marked by concrete block 5 inches (13 cm.) square on top and lettered C. I. W. 1911. True bearings: northwest corner of lunatic asylum, 55° 41′.2; left corner near eaves of Cricket Club grand-stand, 123° 49′.5; lower tip of small white upright over east gable of "Grasmere," the surveyor-general's bungalow, 177° 26′.0; nearest corner of office building, 212° 07′.

Station *C* is 84.62 feet (25.79 meters) south 177° 26′.0 west from *A*.

ISLANDS, PACIFIC OCEAN.

EASTER ISLAND.

Cook Bay, Easter Island, 1916.—Near shore of Cook Bay, Easter Island, on first small point south-southwest of boat landing, on fairly level ground, about 15 feet (5 meters) above sea-level, at a point in line between two beacons, 137.0 feet (41.76 meters) southeast of one, a barrel beacon set on a rough rock and cement pyramid about 8 feet (2.4 meters) high, with an iron rod and shield projecting upward from middle, and 162.7 feet (49.59 meters) northwest of the other beacon, a triangular shield with black center, mounted on a heavy iron rod set in a concrete block, adjacent to and outside of a high stone fence; marked by a block of concrete and cement work, about 14 inches (36 cm.) square, set about 2 feet (0.6 meter) into ground and projecting about 2.5 inches (6 cm.) above ground, with top surface marked C. I. W. 1916. True bearings: barrel beacon, 142° 17′.6; landing beacon, 238 paces, 209° 19′.1; plaza flagstaff, 268° 06′.0; triangular beacon, 322° 20′.3.

HAWAIIAN ISLANDS.

Sisal, Honolulu Magnetic Observatory, Oahu Island, 1915, 1921.—Observations were made on *Pier A* in

ISLANDS, PACIFIC OCEAN.

HAWAIIAN ISLANDS—*continued.*

absolute house, Honolulu Magnetic Observatory, of United States Coast and Geodetic Survey, and at stations *A* and *B*, in 1915, and stations *Pier A* and *A* were reoccupied in 1921.

Station *A* is outside observatory inclosure, 18.46 meters north of *Pier A*, in line with north meridian mark which is distant 2,800 feet (853 meters), on level coral plain 6.4 meters north of stone wall surrounding inclosure; marked by wooden peg with copper tack at precise point. True bearings: trigonometric staff on mountain, 148° 30′.5; V-cut in mountain, 160° 02′.3; north meridian stone, 180° 00′.0.

Station *B* is 2.8 meters north of south stone wall of observatory inclosure measured from a mark chiseled in wall, 12.50 meters southwest of southwest corner of absolute house, 18.01 meters east of southeast corner vestibule of variation observatory, and 15.70 meters southeast of near corner of thermometer shelter; marked by copper nails in top of hardwood peg. True bearings; southeast corner vestibule variation observatory, 88° 48.1; trigonometric staff on mountain, 148° 39′.5; V-cut in mountain, 160° 07′.9; right corner office building, 202° 12′.5; southwest corner absolute house, 212° 42′.6; Mount Tantalus, 265° 46′.8.

MARIANAS.

Guam, Sumay, 1916.—On hill west of Sumay, Port Apra, on sloping grounds of Commercial Pacific Cable Company, about midway between north end of cement tennis-court and north end of bungalow B, in line between right heavy edge of wireless mast near ground and point 1 foot (30 cm.) north of eaves of bungalow B. Station *A* is 42.0 feet (12.80 meters) northwest of a large tree, 164.3 feet (50.08 meters) northeast of southeast cement porch-pier of bungalow B, 182.6 feet (55.66 meters) southeast of northeast cement porch-pier of bungalow A, 463.7 feet (141.34 meters) southwest of south ventilator of superintendent's house; marked by round instrument peg. True bearings: left edge of house D, 20° 36′.7; left edge of bungalow B, 65° 40′.4; south ventilator of superintendent's house, 233° 44′.6; wireless mast, 260° 02′.3; tip of south ventilator of mess house, 280° 36′.7.

Station *B* is 91.6 feet (28.22 meters) east of *A* in line with wireless mast, 80.1 feet (24.41 meters) northeast of tree, 99.7 feet (30.39 meters) west of near corner of tennis-court; marked by round stake. True bearings: left edge of bungalow D, 32° 03′.3; wireless mast, 260° 36′.7; south ventilator of mess house, 286° 42′.5.

Guam, Cabras Island, 1916.—Close reoccupation of C. I. W. station of 1906, Port Apra, on northern shore of harbor, left of channel leading from main harbor to town of Piti, Guam, near water edge and south of coral reef ledge 25 to 50 feet (8 to 15 meters) high extending along northern shore-line, at a point 60 feet (18.3 meters) west of southwest corner of coal-bunkers, 63 feet (19.2 meters) south of front edge of magazine-house, and 30 feet (9.1 meters) north of low-water edge. True bearings: tip of wind-mill tower at Sumay, 40° 11′.7; right edge of bluff at Oroté Point, 74° 20′.

Guam, Orotè Point, 1916.—Close reoccupation of C. I. W. station of 1906, at entrance of Port Apra, just up over break of beach line on first sandy beach encountered on coming into harbor after passing Orotè Island, 85 feet (25.9 meters) east of a 3-inch field gun, and about 150 feet (46 meters) south of coral-reef edge.

ISLANDS, PACIFIC OCEAN.

MARIANAS—*continued.*

True bearings: flagpole at Piti, 257° 24′.0; right edge of wireless mast across harbor, back of town of Agaña, about 8 miles (13 km.), 166° 12′.4.

SAMOAN ISLANDS.

Apia, Samoa Observatory, Upolu Island, 1921.—Five stations were occupied, two in the absolute observatory, *N. Pier*, used for declination and horizontal intensity, and *S. E. Pier*, used for inclination, and three in the observatory grounds, *A*, *B*, and *West Pier.*

West Pier has been used in previous intercomparison work. Before beginning observations in 1921 this pier was tested and found to be magnetic, hence two other stations, *A* and *B* were established.

A is 50.51 feet (15.40 meters) from the northwest corner and 48.53 feet (14.80 meters) from the southwest corner of the concrete base of the atmospheric-electric laboratory. The distance from *A* to the rain-gauge is 26.82 feet (8.17 meters).

B is 50.32 feet (15.34 meters) west of *A* and in line with *A* and the main mark, church steeple to west across the bay. *B* is 51.12 feet (15.58 meters) from the rain gauge and 26.10 feet (7.96 meters) from the square pier north of the absolute observatory.

Both stations *A* and *B* were marked with circular brass-bound tripod pegs. *A* was later marked with a cement post 7 by 7 by 30 inches (18 by 18 by 76 cm.), with a hole in top face to mark the exact spot. The top of post was set 2 inches (5 cm.) below the surface of the ground.

True bearings from *Apia A*: church steeple across the bay to the southwest, 43° 28′.8; church steeple across the bay to the west, 95° 46′.6; gable of house on Faleuli Point, 114° 01′.2; northeast corner of Gauss House in Observatory Grounds, 340° 23′.0.

Pago Pago, Tutuila Island, 1916.—Close reoccupation of C. I. W. station of 1911, on parade-ground of Fita-Fita barracks at U. S. naval station in Pago Pago harbor, at a point south of pathway 162.8 feet (49.62 meters) west-southwest of northwest corner of jail connected with barracks, 78.5 feet (23.93 meters) east-northeast of northeast corner of nearest house, 322.0 feet (98.15 meters) southeast of northeast corner of schoolhouse, southeast of and in line with bandstand and flagstaff, 254.2 feet (77.48 meters) south-southwest of concrete astronomical pier about 2 feet (0.6 meter) high and 2 feet (0.6 meter) square, and in line with center of pier and northwest corner of Fita-Fita wash-house; marked by peg left flush with ground. True bearings: lower near corner of nearby house, 65° 05′.6; monument or survey stone in front of Ho Ching's house, 97° 18′.9; astronomical pier, 200° 01′.2; near gable of judge's house, 240° 45′.7; tip of smoke-stack of power-house, 0.25 mile (0.4 km.), 241° 48′.0; bottom of northwest pier of jail, 265° 04′.8.

SOCIETY ISLANDS.

Point Fareute, Tahiti Island, 1920.—Station of 1920 is close reoccupation of that of 1916, and both are close reoccupations of C. I. W. station of 1906. On coral beach, east of site of old arsenal, 1.2 meters south of high-water line, about 360 feet (110 meters) north of northeast corner of iron bridge across stream, about 20 meters east of (changeable) mouth of stream 20.85 meters west of wire fence along roadway, 12.7 meters southwest of coconut tree, and 5.7 meters southwest of small rivulet. True bearing: north gable of yellow house, 22° 22′.2.

EXTRACTS FROM INSTRUCTIONS FOR CRUISES AND OBSERVATIONAL WORK ON THE CARNEGIE.

The following extracts from the official instructions to those in command of the *Carnegie*, from time to time, will serve to explain the routes prescribed for the vessel and the methods of observation adopted for the various kinds of work. They will aid in showing how the observations were made at successive stages of the work, and how the methods and instrumental appliances were developed and modified as experience suggested. It will be noticed that, although the *Carnegie* is a strictly nonmagnetic vessel, nevertheless the instructions called for occasional swings of the vessel in order to make desired tests, both as to the absence of ship deviations and of "instrumental deviations" (Vol. III, p. 18). From the discussion on pages 179 to 183 it will be seen that the observations made on these swings served a useful purpose, and gave the means of judging as to the accuracy of determination of magnetic elements aboard the *Carnegie* under harbor conditions.

CRUISE IV OF THE CARNEGIE, 1915-1917.

FROM ROUTE INSTRUCTIONS TO J. P. AULT.

(I) February 2, 1915, at Brooklyn.—*a*. The route and ports for Cruise IV of the *Carnegie*, given below, are hereby approved as far as Port Lyttelton, New Zealand, which port is to be reached, if possible, about the middle of October 1915. The route to Port Lyttelton is tentatively sketched on the map supplied, it being understood, of course, that any variation as required by conditions encountered will be left wholly to the commander's discretion.

b. Respecting the question of stopping at Guam on the trip from Dutch Harbor to Port Lyttelton, it would appear that considerable delay might ensue when leaving Guam. You may, accordingly, omit this port on the southward trip. . . . .

c. For the balance of the cruise, beginning at Port Lyttelton, a chart is being prepared showing the magnetic data at present available in the regions concerned. . . .

(II) February 17, 1915. You are hereby authorized to carry out the circumnavigation of the region between parallels 50° and 60° south, beginning at Lyttelton, proceeding in an easterly direction to South Georgia and thence to Lyttelton, as indicated on the attached map. . . .

(III) September 4, 1915, at Lyttelton.—*a*. If circumstances permit it will be highly desirable to amplify the track already proposed from Kerguelen to Port Lyttelton in the manner tentatively shown on the attached map. This will provide an intersection with the *Carnegie's* 1911 track in the Indian Ocean, and will cover better the area south of Australia. If it should be necessary, in order to accomplish this, to make some Australian port, for example, Adelaide, Melbourne, or Hobart, you are authorized to do so. . . .

b. The desirable tracks to be covered by the *Carnegie* in 1916 are shown on the attached map. . . . The main purpose is to secure as many intersections as possible with previous tracks for determination of secular change and for control observations, covering the intervening gaps between our various tracks, and especially strengthening the work of the *Galilee* in the North Pacific Ocean. . . .

(IV) September 23, 1915, at Lyttelton.—*a*. As it may be some time before the *Carnegie* again enters the Pacific, it is desirable to obtain more secular land data in the western part of the ocean. . . . It, therefore, is probable that Guam may be included in the approved homeward track. It is also desirable to reduce the large uncovered areas

immediately northwest and northeast of Easter Island, which lie in the southeast trades. The route modified accordingly is sketched on the attached map. . . .

b. The track approaching and leaving Panama will be left largely to the discretion of the commander, as the best course would depend upon the actual wind directions encountered.

(V) March 8, 1916, at Lyttelton. At Guam please obtain as much information as possible regarding sites for a magnetic observatory. . . .

(VI) May 17, 1916, at Pago Pago. A consideration of all points involved concerning the work of the Department during 1916 and 1917 has made necessary a revision of the balance of the cruise of the *Carnegie*. . . . The changes are, in the main, as follows:

a. The substitution of San Francisco in place of San Diego.

b. Instead of proceeding to Balboa from Easter Island, the cruise will be continued round the Horn to Falkland Islands, thence to St. Helena and finally New York. . . .

c. General examinations of sites for possible observatory use are to be made at Easter Island, Falkland Islands, and St. Helena, according to directions already given for Guam. . . .

[In his supplementary instructions, the commander was authorized to substitute Buenos Aires for Falkland Islands, and to close the work of Cruise IV at Buenos Aires in March 1917, owing to the entry of the United States in the world war. The adopted ports of call for Cruise IV were as follows: Brooklyn, Greenport, Cristobal, Balboa, Honolulu, Dutch Harbor (Alaska), Lyttelton, South Georgia, Lyttelton, Pago Pago (Samoa), Guam, San Francisco, Easter Island, and Buenos Aires.]

INSTRUCTIONS OF FEBRUARY 18, 1915, FOR SCIENTIFIC WORK ON CRUISE IV.

(I) *Magnetic work.*—*a.* The general program of work under this head will be the same as on previous cruises, the observations, as heretofore, being promptly reduced and mailed to the office of the Department. Specific directions as to instruments will be found with the data giving instrumental constants.

b. In view of the new conditions, caused by the recent structural work and alterations of vessel and by the installations of the atmospheric-electric instruments within close proximity to the mounts for the magnetic instruments, it will be highly desirable to swing vessel and make complete observations as often as conditions may permit, in order to make certain the absence of deviation-corrections. During these swings, the atmospheric-electric instruments are to be in place, and in operation, just as when the regular observations with these instruments are made. It may suffice, for the present year (1915) to make these swings at Gardiners Bay, Colon (or Panama), Honolulu, Dutch Harbor, and Port Lyttelton. In view of the possibility of local disturbance at some of these ports, especially Honolulu, and perhaps also Dutch Harbor, it will be desirable to make some swings also at sea. The aim should be to get as large a range in magnetic latitude as possible.

c. The shore observations at Gardiners Bay may be omitted. The shore work at Colon (or Panama) may be restricted to the absolutely essential observations and comparisons. At Honolulu, where a longer stop is contemplated, the shore observations and comparisons of instruments will be made according to the complete scheme for such work. Here also comparisons will be obtained with the magnetic standards of the Honolulu Magnetic Observatory. The shore observations and comparisons at Dutch Harbor, in view of the high magnetic latitude, should be made as complete as conditions will permit. Similar observations on arrival of the vessel at Port Lyttelton will be made at the Christchurch Magnetic Observatory, and an intercomparison of standards will be secured. Information regarding the shore stations and the places where the *Galilee* was swung at Honolulu and Port Lyttelton is supplied on separate sheets.

(II) *Atmospheric-electric work.*—*a.* The detailed directions supplied for observations under this head will be followed.[1] With the addition of another observer to the vessel's scientific staff, it will now be possible to assign one observer practically entirely to the atmospheric-electric work. However, in order to secure simultaneity of determination of the various electric elements, it will be necessary to have also an auxiliary observer take part in this work. The principal observer, in return, will give any assistance required in the successful execution of the other work of the *Carnegie.*

(III) *Atmospheric-refraction work.*—The observations will be made in accordance with the detailed directions supplied.[1] It is hoped that special attention will be paid to these observations, in order to secure desired improvement.

(IV) *Barometer and boiling-point work.*—See pages 132 and 134.

(V) *Meteorological observations.*—See pages 132 and 135.

(VI) *Astronomical observations.*—See pages 132 and 135.

DIRECTIONS OF MARCH 6, 1916, FOR EXPERIMENTAL APPARATUS No. 1 FOR RECORDING SHIP'S MOTION.

(1) Inclosed herewith are directions and notes for using experimental apparatus No. 1 for recording ship's motion. . . .

(2) This apparatus is a camera mounted to turn about two axes, a vertical and a horizontal, and is designed to record the motion of the ship over a short period by making a quick succession of instantaneous exposures of the sun while the camera is rigidly fixed to the ship.

CRUISE V OF THE CARNEGIE, 1917–1918.

FROM ROUTE INSTRUCTIONS TO H. M. W. EDMONDS.

(I) *August 3, 1917, Buenos Aires.*—*a.* In accordance with the authorization received from President Woodward, please make all necessary arrangements for the carrying out of a cruise of the *Carnegie,* to be known as Cruise V, and to be approximately as follows:

Leaving Buenos Aires not later than November 15, 1917, the *Carnegie* is to proceed to the Straits of Magellan, reporting her arrival at Punta Arenas and awaiting there any cable instructions from the office. The plan would be to have the vessel towed through the Straits. . . . The vessel's passage through the Straits could probably be wired to the office, through the tugboat, either from Cape Pillar or from Punta Arenas.

The vessel would then proceed to Talcahuano, Chile, and possibly also to Valparaiso, her arrival at the first Chilean port being again reported, and cable instructions from the office awaited.

The *Carnegie* is thence to proceed to Callao, Peru, where arrival would again be reported to the office, and cable instructions once more awaited.

From Callao the cruise would be continued according to the circumstances at the time, either to San Francisco direct or to San Francisco via Honolulu. It may possibly even develop that the *Carnegie* would proceed from Callao to Balboa, and thence to an American port if conditions permitted. . . .

b. It will be observed that the cruise as tentatively outlined implies calls at various ports where, if conditions make it necessary, the cruise may be discontinued and the vessel may be laid up. Only sufficient time is to be allowed at Punta Arenas and Talcahuano (or Valparaiso) for reoccupation of previous magnetic stations; comparisons of instruments, after the work of this character has been completed at Buenos Aires, will not be required again until Callao is reached. By mutual cooperation, it will be

[1] The detailed directions are described in the special reports dealing with the various kinds of work. For those pertaining to the atmospheric-electric work, see pages 266 to 276.

possible for the office and the vessel to keep in effective communication, and thus make possible any alterations in plans which prevailing conditions may cause. . . .

(II) *October 5, 1917, Buenos Aires.*—On account of the unsettled conditions in Argentina and of the liability of interruption to telegraphic communication between Washington and Buenos Aires, it seems best to give you your final sailing instructions now by mail. If the above contingency should arise and you are unable to obtain confirmation of sailing orders by cable, you are hereby authorized to sail at your discretion when ready. The date of sailing should be as near November 15, 1917, as possible.

(III) *February 7, 1918, Callao, Peru.*—Since it has been decided to omit the portion of the cruise including Honolulu, the following will be your route instructions after leaving Callao, as decided upon in conference with President Woodward:

a. From Callao please proceed to Balboa, Canal Zone, following route *a* as shown by the dotted line on the attached route map.

b. If not otherwise instructed at or before reaching Balboa, or Colon, proceed to Newport News, with New York as an alternative, following, as nearly as conditions permit, the route *b* shown by the dotted black line on the attached route map, and calling at San Juan, Porto Rico, on the return from the eastward loop indicated on the map, to report and to receive final instructions as to home port.

(IV) *April 17, 1918, Balboa, Canal Zone.*—It has been found essential to bring the *Carnegie* back to an Atlantic port at the earliest possible date. It therefore becomes necessary to omit the extension (loop eastward of San Juan, Porto Rico) as indicated in route *b* of your "Route Instructions" dated February 7, 1918. You will accordingly proceed by this route directly from Colon to Newport News, omitting San Juan.

INSTRUCTIONS OF SEPTEMBER 28, 1917, FOR SCIENTIFIC WORK ON CRUISE V.

(I) *Magnetic work.*—*a.* The general program of work under this head will be the same as carried out during Cruise IV, the observations, as heretofore, being promptly reduced and mailed to the office of the Department. Any specific directions as to instruments will be found in attached letter giving information as to the constants of the various instruments, dated September 28, 1917 (No. A1).

b. In order to determine the possibility of deviation corrections, harbor swings will be made wherever conditions are especially favorable, particularly at San Francisco, where previous swings have been made. It will probably not be possible to swing in any of the South American harbors to be entered during Cruise V. Pearl Harbor has also been shown by past observations not to be a satisfactory place for swings. Accordingly, every opportunity to swing under excellent conditions at sea, remote from local disturbances, should be taken.

In swinging ship care will be taken to make the headings with each helm as symmetrical as possible about the center of swing and to note any divergence therefrom. The various headings for the respective helms will be made whenever possible in chronological order, and any necessary departure therefrom will be noted on the record and the reason given. A position by bearings will be obtained for each heading, if possible, and the deviations of the steering compass will be obtained on at least one complete helm.

c. The Argentine magnetic station at Punta Arenas will be reoccupied or, if unsuitable for reoccupation, a new station will be established. A description of the station is to be obtained by you from the Argentine Meteorological Office. The C. I. W. station at Talcahuano will be reoccupied, as well as the one at Valparaiso if a call is made at the latter port. A complete program, as far as possible, of intercomparisons of instruments will be carried out at Callao, e. g., constants will be determined for such instruments, magnets, and distances as have been in use since leaving Buenos Aires and as might be used for the continuation of the cruise. At Honolulu the complete

program will be carried out and comparisons of the various *Carnegie* instruments will be obtained with those of the United States Coast and Geodetic Survey Magnetic Observatory, as on previous occasions. Likewise, at San Francisco complete intercomparisons of our instruments will be obtained.

(II) *Atmospheric-refraction work.*—The observations will be made in accordance with the detailed directions supplied herewith. It is hoped that special attention will be paid to these observations, in order to obtain as great certainty as possible in the results. Since particular interest is attached to good observations obtained under this head, special care will be used in guarding the instruments from injury and in noting on the record sheet all pertinent data. Likewise advantage will be taken of every opportunity to make any of the auxiliary observations called for in the following detailed directions:

1. *Observations are to be made three times daily,* as heretofore, with dip measurers Zeiss Nos. 4048 and 5490. Whenever practicable the observations will be made on the bridge, simultaneous with the regular meteorological observations, as also at such times when the meteorological conditions, for one reason or another, are abnormal, as is especially likely to occur on approaching cold waters, or in the vicinity of land. In order to vary the conditions, additional observations, at higher elevations than the bridge, will be made at sea, when favorable opportunities permit.

2. *The observations, with all pertinent data, will be entered on the usual forms* and the following conventions will be adopted for each instrument in its normal position for observing. The algebraic signs will always be entered in the record.

Positions	Readings	Dip measurers Nos. 4048 and 5490
Erect	E	When the scale is erect.
Inverted	I	When the scale is inverted.
E and I are positive	(+)	When the sea-images overlap.
E and I are negative	(−)	When the sky appears between the sea-images.

3. *The units of the scale* in Zeiss No. 4048 express minutes of arc; one unit of the scale in Zeiss No. 5490 corresponds to 1ʹ.01 in arc of elevation or depression of the sea-horizon.

4. *The dip of the horizon* is given by $\frac{1}{2}(E+I)$; its sign is *negative* when the apparent horizon is below the mathematical horizon.

5. *Assuming two observers, A and B, available, the order of observation will be as follows:* A to make all the observations from Buenos Aires to Punta Arenas, B to make all the observations from Punta Arenas to Callao, then A from Callao to Honolulu, and B from Honolulu to San Francisco.

6. *Observations will be made at sea* when conditions permit and when they can be secured without delay as follows: Simultaneous observations with both dip measurers and a sextant or circle, the dip-of-horizon to be obtained with the latter instruments by measuring altitudes of the Sun or other celestial body from opposite horizons, when the body is near the zenith.

7. *Observations will be made in port* when conditions permit and when they can be secured without undue delay or expense as follows:

a. On land, simultaneous observations with both dip measurers and a theodolite, all three instruments being at the same elevation above the sea. Such observations may be possible by occupying some cape, point of land, or small island. Observations made on some headland at varying altitudes would also be valuable in investigating possible sources of error of the dip measurers. Such observations would permit the

use of the instruments under the most perfectly steady conditions and, hence, would eliminate errors which are due to the ship's motion.

b. On board ship, simultaneous measurements of the sea-horizon with both dip measurers and Sun altitudes with a sextant, all three instruments being at the same elevation, when, at the same time, the ship's position can be determined by bearings. Favorable conditions for such observations occur when the vessel is at anchor in some roadstead, strait, or long bay, or when coasting along a well-marked shore.

8. The attention of observers using these dip measurers will be called to *two sources of error* to be guarded against, if possible, and noted in the record when existing: (*a*) Error due to ship not being on even keel; (*b*) error due to observing in or partly in the trough of the sea. Both errors may be very small, yet they are always in one direction and can not be eliminated by a series of observations.

(III) *Barometer and boiling-point work.*—1. The following observations are prescribed to obtain not only some control over the barometer constant, but also further information on the constants of the hypsometric thermometers on board:

a. Boiling-point determinations will be made at every port, on board ship, simultaneous with, or symmetrically arranged with, barometer readings as heretofore. Arrangements will be made so that any comparisons with standards or substandards ashore will be simultaneous with the above barometer readings during boiling-point determinations.

b. Ice-point determinations will be made on the same day, if practicable, and after the boiling-point determinations.

c. If the vessel passes through the Magellan Strait, boiling-point observations will be made every day during the passage through the Strait.

2. *A careful examination will always be made for detached pieces of the mercury column.* These can be united to the column by means of an oil bath, care being taken not to heat the thermometer any more than is necessary to drive the column into junction with the detached pieces.

(IV) *Meteorological observations.*—1. The *customary meteorological observations* by the watch-officers are to be continued in port, as at Buenos Aires, as well as at sea.

2. The *Greenwich mean noon observations* and the record which will be transmitted through this office to the Weather Bureau will receive especial attention. You will continue to use Weather Bureau list barometer No. 7272, and two copies of the results of these observations will be transmitted to the office. The date and place of the last barometer comparison will be inserted and also the result, if it be available. The geographic positions of the Greenwich mean noon observations will be stated only to the nearest minute.

3. Probably no *standards* will be found with which to compare except at Buenos Aires, Honolulu, and San Francisco. For these comparisons it will not be necessary to remove the barometers from the vessel.

4. The *barometer reading should be the mean of at least 20 readings when there is pumping,* taken, for example, on 5 *successive* highs followed by 10 successive lows and finally 5 successive highs. On account of the skill necessary for these observations and the necessity of sometimes using artificial light (with objectionable heating effects), it is desirable that these observations be made by one trained observer who will always be available at Greenwich mean noon.

5. You will continue to make the usual observations on the occurrence of thunder and lightning at sea, making full notes and transmitting a report at the end of each passage.

(V) *Astronomic observations.*—1. All *astronomic observations at sea* will be made in duplicate at least, and the results will be deduced by independent calculation. As

heretofore, advantage will be taken of every opportunity to determine the geographic position of the vessel.

2. All *positions of magnetic stations* at sea will be corrected for the error of run, except when it is considered inadvisable to do so for special reasons. These reasons will be entered on the appropriate dead-reckoning sheets.

3. The *usual statement as to error of longitudes* due to chronometer error at the end of a passage will be entered on the last sheet of the astronomic observations cahier and on the last sheet of the table of "Results of ocean magnetic observations and comparisons with chart values," together with final and definite statement as to whether the error is large enough or sufficiently well determined to be applied.

4. *Two copies of revised abstract of log* will be forwarded to the office of the Department at the end of each passage.

(VI) *Observations with experimental apparatus No. 1 for recording ship's motion.*—Before departure from Buenos Aires you will see that this instrument is in good working order. During the cruise these observations will be taken as frequently as conditions will permit, in order to determine the value of the instrument and method. As soon as all films on board have been exposed, further instructions are to be awaited before purchasing another supply.

(VII) *Atmospheric-electric work.*—See pages 266 to 276.

CRUISE VI OF THE CARNEGIE, 1919–1921.

The plans for the sixth cruise of the *Carnegie* were prepared by Captain Ault. The route instructions for the two-years' voyage of 1919 to 1921, as finally approved by the Director, included the following ports: Old Point Comfort, Dakar, Buenos Aires, St. Helena, Cape Town, Colombo, Fremantle, Lyttelton, Papeete, San Francisco, Honolulu, Pago Pago and Apia (Samoa), Rarotonga, Balboa, Old Point Comfort, and Washington. Brief calls were made at Fanning Island and at Penrhyn Island and Manihiki Island of the Cook Island Group.

INSTRUCTIONS OF OCTOBER 7, 1919, FOR SCIENTIFIC WORK ON CRUISE VI.

(I) *Magnetic work.*—*a.* The general program of work under this head will be the same as carried out on cruises IV and V, the observations, as heretofore, being promptly reduced and mailed to the office of the Department. Any specific directions as to instruments will be found in the attached letter of even date, No. F3, with constant-data sheets for the various instruments.

b. In order to determine the possibility of deviation-corrections, particularly so in view of the recent installation of the small gasoline engine, which is not nonmagnetic, and the reconstruction and alteration of the main engine, *harbor swings* will be made wherever conditions are especially favorable, particularly in Chesapeake Bay at the point where the concluding swings for Cruise V were made in June 1918. A copy of C. and G. S. chart 1224, Chesapeake Bay, Smith Point to Cove Point is attached, upon which are marked the positions for the declination swing and horizontal-intensity and inclination swing of June 9, 1918; please note that the results of land observations made during June 27 to July 8 at stations surrounding this place of swing are indicated in pencil. The values given are reduced on the basis of International Magnetic Standard. A slight irregularity is indicated, but is not sufficient to affect the sea observations. Single copies of descriptions of stations occupied by Messrs. Fisk, Mills, and Grummann, together with a copy of Mr. Fisk's report on the field work executed in Chesapeake Bay and a summary of the magnetic results obtained, are attached. If local conditions are favorable, it will be desirable to secure a swing also near Buenos Aires and near Aden.

Past observations show Lyttelton and Pearl Harbor not to be suited for swing observations; most of the ports reached in the Pacific islands are also probably locally disturbed. Accordingly, opportunity should be taken to swing under excellent conditions at sea remote from local disturbances.

c. In swinging ship care will be taken to make the headings with each helm as symmetrical as possible about the center of swing, and to note any departures therefrom. The various headings for the respective helms will be made wherever possible in chronological order, and any necessary departure therefrom will be noted on the record and the reason given. A position by bearings will be obtained for each heading, if possible, and the deviations of the steering compass will be obtained on at least one complete helm.

d. Shore observations for intercomparisons of instruments, for secular change, and for intercomparison at observatories will be carried out in accordance with the notes attached to the schedule of Cruise VI, which accompanied your letter A1 of September 22. A curtailed program of intercomparison of ship instruments is to be prepared by yourself and Mr. Fleming before the latter leaves the vessel. It is desired that the intercomparisons be curtailed as greatly as the limit of error for ocean work will permit.

(II) *Atmospheric-electric work.*—See section on atmospheric-electric results during cruises IV, V, and VI, pages 266 to 276.

(III) *Atmospheric-refraction work.*—The same general methods and forms will be used as on cruises IV and V. In addition please note:

1. Observers should be changed at each port in rotation in order to collect additional data on systematic personal errors.

2. The draft of the vessel should be recorded in the cahier on leaving and upon arriving at each port.

3. The height of eye should be carefully determined in port for a stated draft and any variations noted for each observer which would apply when bracing himself in the position he will usually assume for observing at sea.

4. The temperature of the air is to be determined at an altitude equal to that of the eye.

5. The temperature of the sea water is to be determined by the same thermometer, or, if two are used, sufficient comparisons are to be made between the two thermometers to insure against an error of not more than 0°.1 in the air-water temperature difference.

6. Probably one of the most important sources of discrepancies between results for different passages is the varying height and length of waves. Both the height and length are difficult to measure with accuracy, but an estimate should be added to each complete set of observations. It is suggested that the height and length of waves be determined by the usual methods given in the hydrographic publications as often as may be found practicable in order to guide observers in their estimates.

7. Care should be taken to follow previous work on the *Carnegie* in taking observations on even keel and when riding the wave.

(IV) *Barometer and boiling-point observations.*—1. The following observations are prescribed to obtain not only some control over the barometer constants but also further information on the constants of the hypsometric thermometers on board:

a. Boiling-point determinations will be made at every port, on board ship, simultaneous with, or symmetrically arranged with, barometer readings as heretofore. Arrangements will be made so that any comparisons with standards or substandards ashore will be simultaneous with the above barometer readings during boiling-point determinations.

b. Ice-point determinations will be made on the same day, if practicable, and after the boiling-point determinations.

2. *A careful examination will always be made for detached pieces of the mercury column.* These can be united to the column by means of an oil bath, care being taken not to heat the thermometer any more than is necessary to drive the column into junction with the detached pieces.

(V) *Meteorological observations.*—1. The *customary meteorological observations* are to be continued, in port as well as at sea.

2. The *Greenwich mean noon observations* and the record which will be transmitted through this office to the Weather Bureau will receive especial attention. You will continue to use the standard Weather Bureau form and transmit two copies of the results of the observations to the office. The date and place of the last barometer comparison will be inserted and also the result, if it be available. The geographic positions of the Greenwich mean noon observations will be stated only to the nearest minute.

3. For those ports at which *standard barometer comparisons* are possible, simultaneous readings will be made of the port standard and the ship's barometers always to be kept mounted on the vessel.

4. The *barometer reading should be the mean of at least 20 readings when there is pumping*, taken, for example, on 5 *successive* highs followed by 10 successive lows and finally 5 successive highs. On account of the skill necessary for these observations and the necessity of sometimes using artificial light (with objectionable heating effects), it is desirable that these observations be made by one trained observer who will always be available at Greenwich mean noon.

5. You will continue to make the *usual observations on the occurrence of thunder and lightning at sea*, making full notes and transmitting a report at the end of each passage.

6. In accordance with letter B1 of October 6 and the copy of letter dated October 5 from Professor W. J. Humphreys, attached thereto, cloud photographs should be made if it is convenient. Professor Humphreys' letter indicates the general requirements sufficiently.

(VI) *Astronomic observations.*—1. All *astronomic observations at sea* will be made in duplicate at least, and the results will be deduced by independent calculation. As heretofore, advantage will be taken of every opportunity to determine the geographic position of the vessel.

2. All *positions of magnetic stations* at sea will be corrected for the error of run except when it is considered inadvisable to do so for special reasons. These reasons will be entered on the appropriate dead-reckoning sheets.

3. The *usual statement as to error of longitudes* due to chronometer error at the end of a passage will be entered on the last sheet of the astronomic observations cahier and on the last sheet of the table of "Results of ocean magnetic observations and comparisons with chart values," together with final and definite statement as to whether the error is large enough or sufficiently well determined to be applied.

4. *Two copies of revised abstract of log* will be forwarded to the office of the Department at the end of each passage. This abstract is to be made in accordance with the memorandum instructions and specimen form attached hereto.

(VII) *Observations of ship's motion with automatic roll-and-pitch recorder.*—Records should be obtained with the gyro roll-and-pitch recorder supplied, in accordance with the special memoranda attached to the constants for that instrument and in accordance with the general directions supplied by the Sperry Gyroscope Company. Further instructions with reference to this work will be sent you from time to time as you report upon it.

1. *Location.*—The choice of location on board ship should be governed by the following considerations seriatim:

a. It should be remote from the magnetic instruments, since it is constructed of steel.

b. It should be well sheltered against weather and sea.

c. It should be readily accessible.

2. *Installation.*—The instrument should be installed according to "Description and instructions" issued by the makers, and accompanying these instructions. Accordingly, the short dimension of the base is to be *exactly parallel* with the fore-and-aft axis of the ship. The instrument may therefore be oriented with the gyrostat on the port side of the recording sheet, or *vice versa,* as may be found convenient in case of starting, stopping, clamping, or for removing and renewing the record. The orientation, however, should be *noted,* so that the roll to port may be distinguished from the roll to starboard. The ring clamp (15340-B) should always be clamped, either to hold the gyrostat when the latter is not operating, or to prevent the clamp from slipping when the gyrostat is operating. The "Description, etc." should be read carefully.

3. *Use.*—In the absence of actual experiments with the instrument at sea and a positive knowledge of what data may be required for future corrections of dynamic deviations, it will be desirable to run the roll-and-pitch recorder during *all magnetic observations,* starting the gyrostat about 15 minutes before observations begin. The recording apparatus may be started later, say about 3 to 5 minutes before magnetic observations, and shut off immediately at end of magnetic observations in order to save paper.

For identification, the time and date of 10-second indentation at the beginning of the *record* should be scratched on the record sheet, noting the time by the same watch that is to be used in the magnetic observations. The time should be noted also at one of the last 10-second indentations and written opposite to the indentation on the record sheet. The reference of these time marks to the roll-and-pitch records corresponding will depend upon the distance between the time-marking needle and the roll-and-pitch marking needles; these distances should be noted for each record.

When the current has been cut off at the end of a record, the gyrostat should be allowed to swing freely until the revolutions of the gyrostat are visible, after which the gyrostat should be clamped first by the clamp at the bottom and finally by the ring clamp (15340-B).

For the purpose of correlating the records of motion made on earlier cruises, the notes regarding rolling and pitching will be made as on earlier cruises where called for on the observation forms, the data being taken from the clinometers as heretofore.

The auto roll-and-pitch recorder sheets should be preserved in tubes and mailed in tubes at each port of call.

4. *Constants.*—The scale on one of the guide strips (13055) is approximate, each division representing about one degree of roll or pitch.

5. *Limit for pitch.*—It should be noted that the record for pitch is limited to about 10° or 12°, and the instrument should not be used when this limit is approached.

(A typical record of roll and pitch as obtained aboard the *Carnegie* with the Sperry automatic recorder is shown in Fig. 3.)

(VIII) *Instructions for swing observations, October 7, 1919.*—The following instructions will govern the swing observations (1) in Chesapeake Bay at a point about half-way between Point No Point and Cedar Point, southwest of Hooper Island Lighthouse at the beginning of Cruise VI, (2) other swing observations during Cruise VI.

Make declination observations, using both M. C. C. 1 and deflector 5 while swinging ship with two helms, port and starboard, steadying on the eight cardinal and inter-

cardinal points for each helm. A sufficient number of observations should be taken to insure good results.

2. Make intensity observations with deflector 5 and dip and intensity observations with sea dip-circle 189 while swinging ship with two helms as above.

The observations with deflector 5 should consist of deflections with magnet 5, distance 1, vernier *A*, for one helm, and magnet 2L, distance 3, vernier *B*, for the other helm. You will see that this is only half the usual program for each magnet, thus reducing the time required for each heading and reducing the region covered during the swing.

The observations with sea dip-circle 189 should consist of deflection observations with intensity needles 3 and 4, one distance complete on each heading for one helm, and the other distance for the second helm.

The lighthouses and other prominent marks are sufficiently numerous to permit keeping control of the position of the vessel, which should be done for each heading. The attempt should be made to have all headings so arranged in position when plotted as to insure symmetry about the center of swing. A prominent buoy, anchored at the middle point of the swing, would be of great assistance.

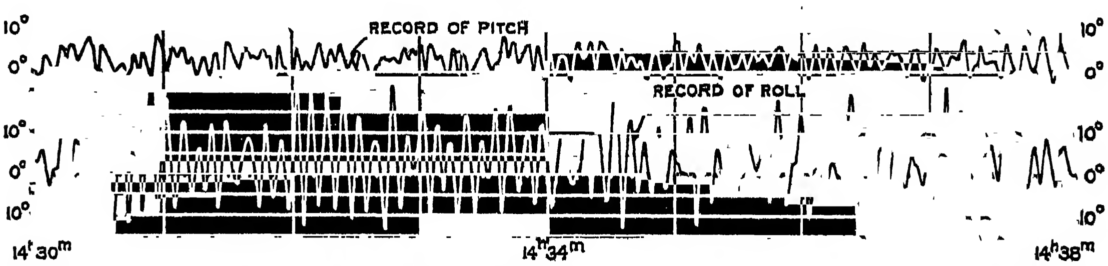


FIG. 3.—Record of Ship's Motion as obtained with Sperry Gyroscopic Roll-and-Pitch Recorder aboard the *Carnegie*, November 2, 1921.

Preliminary computations during the observations will show whether or not any of the headings should be repeated.

(IX) *Supplementary instructions for Cruise VI, October 15, 1919.*—The following instructions, in addition to the Department's General Directions for Magnetic Observations, will apply for the shore work and for the observatory intercomparisons at ports of call during Cruise VI of the *Carnegie.*

1. Observations for secular changes only are to be made at St. Helena, Fanning Island, and Colon.

2. The complete program of intercomparisons and standardizations of ship instruments as followed in the past work of the *Carnegie* will be carried out only at Aden and at Watheroo, these points giving extreme range in dip. Note that for this work the three orientations of footscrews will be used for the magnetometer, sea dip-circle, and earth-inductor work, and that the orientations 0°, 90°, 180°, and 270° will be used for intensity work with deflector 5, and orientations 0° and 180° for a. m. and p. m. declination work with deflector 5; the determinations of constants for marine collimating-compass 1 will consist of observations for the values of A_{cS}, A_{cW}, A_{cN}, A_{cE}, m_S, m_W, m_N, and m_E, two determinations being made for each constant, making the round forward for the first determination and in the reverse direction for the second.

3. A curtailed program of intercomparisons and standardizations will be carried out at Dakar, Buenos Aires, Cape Town, Lyttelton, Papeete, Honolulu, and Samoa. The curtailment over the complete program will be as indicated below and will reduce the time required for the shore work to five days or less, depending of course largely upon the meteorological conditions prevailing.

a. The preliminary work to be done on the first day will consist of the careful selection of two stations to be designated *A* and *B* to be set preferably in line with a distant azimuth mark; the determination of a. m. and p. m. azimuth and local mean time by observations on the sun; circummeridian observations of the sun for latitude; the securing of measurements, sketches, photographs, and other matter for full description of stations.

b. The instrumental work will consist of simultaneous observations at stations *A* and *B*, in accordance with the following skeleton outline (it is to be noted that the order of procedure indicated in the outline may have to be altered to take advantage of prevailing meteorological and other local conditions and that the instruments will be mounted invariably with one footscrew orientation only, namely, footscrew *A* to the south):

CURTAILED PROGRAM FOR SHORE STATIONS.

Station A.	*Station B.*
M. 5, *A* south, *D*, *H*,[a] 2 sets.	M. 25, *A* south, *D*, *H*,[a] 2 sets.
M. 25, *A* south, *D*, *H*,[a] 2 sets.	M. 5, *A* south, *D*, *H*,[a] 2 sets.
M. 25, *A* south, *I*, 2 sets.	E. I. 7, *A* south, *I*,[b] 2 sets.
E. I. 7, *A* south, *I*,[b] 2 sets.	M. 25, *A* south, *I*, 2 sets.
C. D. C. 189, *A* south, *I* and *F*,[c] 2 sets.	M. 25, *A* south, *H*,[a] 2 sets, and *I*, 4 sets, alternating (thus, *I*, *H*, *I*, *I*, *H*, *I*).
D. 5, *H*, orientations 0°, 2 sets, and 180°, 2 sets.	M. 25, *H*[a] throughout D5 work.
D. 5, a.m. *D*. or p.m. *D*., altitude 0° to 30°.	M. 25, *D* (axis, scale erect readings, axis).

[a] Deflections at two distances only; a magnetometer set will consist of the following observations: declination, oscillations, deflections, deflections, oscillations, and declination.

[b] One set, commutator up, and one set, commutator down.

[c] Set with sea dip-circle 189 will consist of the following observations; polarity *A* with the two dip needles regularly used, loaded dip with weighted needle of the intensity pair regularly used, deflected dip with intensity pair regularly used, for short distance direct and reversed, deflections long distance direct and reversed, deflections long distance direct and reversed, deflections short distance direct and reversed, loaded dip, polarity *B* for the two dip needles.

4. Observatory intercomparisons, with the complete program for magnetometer and earth-inductor work as heretofore used, will be made at Watheroo, Lyttelton, Honolulu, and Samoa (note that no observatory intercomparisons are to be undertaken from Buenos Aires for the observatory at Pilar), in accordance with the Department's memoranda regarding intercomparisons of magnetic instruments and standards at observatory stations. These memoranda emphasize the points concerning which particular caution must be observed for such work; they are the result of the accumulated experience of Department observers over the last ten years.

5. Magnetometer 5 should be considered as the standard declination and intensity instrument, its past record having indicated its superiority particularly in intensity work. The program is so arranged that after the magnetometer intercomparisons this magnetometer should be returned to the ship; the magnetometer to be used for intercomparison of ship instruments is 25.

EXTRACTS FROM FIELD REPORTS AND ABSTRACTS OF LOGS OF THE CARNEGIE, 1915-1921.

Synopses of the cruises of the *Carnegie*, 1915–1921, will be found on pages 6 to 21. The abstracts of the logs of the *Carnegie*, given on pages 144 to 170, contain more detailed information as to the various passages of the vessel and the conditions encountered on them.

The extract from the report of the circumnavigation trip of the *Carnegie* in sub-Antarctic regions, published in Volume III, Researches of the Department of Terrestrial Magnetism, pages 326–330, is reproduced here, since it describes an important part of Cruise IV, the final results of which are included in this volume.

EXTRACTS FROM FIELD REPORTS.

J. P. AULT: ON THE SUB-ANTARCTIC VOYAGE OF THE CARNEGIE FROM LYTTELTON TO LYTTELTON, VIA SOUTH GEORGIA, DECEMBER 6, 1915, TO APRIL 1, 1916.

I beg to submit the following report on the circumnavigation trip of the *Carnegie* from Lyttelton to Lyttelton via South Georgia, December 6, 1915, to April 1, 1916.

For the first week after leaving Lyttelton the winds were mainly from the SSW, forcing us considerably to the eastward of our route; so much so that we sighted the Antipodes, bearing south, distant 20 miles, on December 9, and would have passed over the charted position of the Nimrod Group had the wind remained in the south another 12 hours. It had not been the intention to go near this group, but the adverse winds sending us so near them, it was decided to stand on toward the east another day, to endeavor to sight them; but the wind shifted to the north 12 hours too soon and we passed 40 miles to the SW of the position. [The Nimrod Islands were stated to have been seen, at a considerable distance, by Captain Henry Eilbech in the *Nimrod* in 1828, who placed them in about 56°.5 S and 158°.5 W.]

On December 7, a mirage presenting the appearance of distinct and extensive land was seen in the west, in the direction of Banks Peninsula, which was 190 miles distant at the time.

We crossed the 180th meridian December 9, so repeated the date as December 9 (2). Our first piece of ice was sighted on December 18, lat. 60° 12′ S, long. 150° 46′ W, and on December 19, 30 icebergs, some being over 400 feet high and 1 mile long, were passed. We had snow on December 18, 19, 20, and 21, and rather wintry weather. The barometer dropped to 28.26 inches on December 18, during the snow storm. No icebergs were seen after December 24 until January 10, just before arrival at South Georgia, when 8 or 10 good-sized bergs were passed.

As our route lay near the charted position of Dougherty Island, we determined to look for it. On the afternoon of December 24, the cry of "land ahead" was given and we saw what appeared to be a bold, dark-rock island. Immediately our course was shaped to pass near it. Everyone was convinced that either a new island had been discovered or that the position given for Dougherty Island was very much in error. It seemed to be a rocky cliff with a snow cap. Nearer approach, however, proved that the supposed island was an iceberg, 225 feet high by one-quarter mile long. The light was reflected from the perpendicular ice-wall in such a way as to give the berg the appearance of a huge dark rock. The morning of December 25 found us within 3 miles of the position given for Dougherty Island. The weather was cloudy but the seeing was good. Nothing could be seen from the masthead. I went aloft myself every half hour while we were passing the position given for the island. Had anything over 100 feet high

been within 35 miles of the vessel in any direction we would have seen it. At 3^h40^m a. m., December 25, Dougherty Island should have been 3 miles SE of us. There was nothing visible within a radius of 35 miles at the time. The island has either been charted in the wrong place, or it has disappeared, or possibly it was an ice-island. Our experience on December 24 would confirm the possibilities of optical illusions. The *Carnegie's* track (see Fig. 1) extended from latitude 59° 28′ S, and longitude 123° 17′ W, to latitude 59° 08′ S, and longitude 110° 10′ W; daylight and good seeing were had all the time. If anyone else attempts to locate the island, he should try either 40 miles south or 40 miles north of the charted position. We assumed the island to be at 59° 21′ S, and between 119° 10′ W and 120° 20′ W. Dougherty Island was supposed to have been seen by Captain Dougherty in the *James Stewart* in 1841, who located it approximately in latitude 59° 20′ S and longitude 120° 20′ W. In 1859, Captain E. Keates in the *Louise* sighted an island, assumed to be Dougherty, assigning the position 59° 21′ S and 119° 07′ W[1] to it.

December 30 and 31 were the first fine days experienced since our departure from Lyttelton. In spite of storms, rain, snow, fog, and prevailing cloudy weather, we succeeded in getting declination observations daily, and averaging twice daily during the entire trip. This was accomplished by taking advantage of every opportunity and spending considerable time standing by. Frequently we would make six or more trips to the bridge before being successful. At other times observations would be made during the only 5 or 10 minutes that the Sun was visible on the entire day.

The winds were mainly from the westerly semicircle; north and northwesterly winds with high and falling barometer, shifting to west and southwest when the barometer began to rise; rain and mist occurred nearly every day. Fogs were quite frequent but not of long duration.

The entire party has enjoyed thus far the very best of health, and the weather has not been very severe. It has been more enjoyable in fact than a trip through the hot tropics.

We arrived at King Edward Cove, South Georgia, January 12, 9^h30^m a. m., going the last 24 hours under our auxiliary power. The total run from Lyttelton to South Georgia was 5,440 miles, or an average of 144 miles for 37.9 days; the total distance logged was 6,010 miles.

The *Carnegie* left South Georgia at 7 p. m., January 14, 1916, towed out of harbor against a heavy head-wind by the steam whaler *Fortuna*. In the following days we realized that we were in climatic conditions quite different from what we had experienced previously. Icebergs appeared in increasing numbers, and fog was almost continuous. We will long remember January 18 as the only day during the entire trip of 4 months when we failed to obtain observations of the magnetic declination. The Sun was visible for only 3 seconds during the entire day, giving no opportunity for observations.

Larger icebergs were seen as we neared Lindsay Island, one looming up through the fog like a vast extent of dark land with the bright ice-blink reflected from the fog above it. We encountered an ice stream where small pieces were too numerous to dodge.

On January 22 we passed along the north coast of Lindsay Island about 3 miles offshore, obtaining a good view of this lonely, desolate place, with its deep mantle of snow and ice, surrounded with the wrecked icebergs that have come to grief on its shoals. A delegation of six penguins came out to greet us, the only ones seen in this vicinity.

The island agrees almost exactly in appearance and outline with the description and sketch given in the British Admiralty's Africa Pilot, Part II, 1910. It was surveyed by the German Deep Sea Expedition of 1898 in the *Valdivia*. They gave the

[1] According to *Nature*, vol. 97, No. 2431, June 1, 1916, p. 237, "in 1909, on the homeward voyage of the *Nimrod*, with Sir E. H. Shackleton's Antarctic Expedition, Capt. J. K. Davis made a thorough search for the Nimrod and Dougherty islands, and failed to find them; they were in consequence removed from the last edition of the Prince of Monaco's bathymetrical chart of the oceans."

position for its center as latitude 54° 26′ S, longitude 3° 24′ E. Our observations place its center in latitude 54° 29′ S, longitude 3° 27′ E, or about 3 miles from the position assigned by the *Valdivia.* This is a very close check in position for these regions, and we had no difficulty in locating the island. When our reckoning had placed it about 10 miles southeast of the vessel, we were able to locate it in the proper direction by noting the outline of a snow-covered glacier which appeared motionless through the shifting rifts in cloud and fog.

Some authorities have called this island "Bouvet Island," thereby causing a little confusion. H. R. Mill, in his book "The Siege of the South Pole," 1905, gives a couple of pages to a description and picture of Lindsay Island, but names it "Bouvet," and gives as its position the latitude and longitude quoted above from the British Admiralty Pilot as that of Lindsay. Both books give as their authority the German Deep Sea Expedition of 1898. The British Admiralty Pilot states that "in November, 1898, the island (Bouvet) was searched for unsuccessfully by Captain Krech, of the German Deep Sea Expedition vessel *Valdivia.* Its position must, therefore, be considered uncertain." We agree with this conclusion, since we check so well the *Valdivia's* position of Lindsay Island.

Stieler's Hand-Atlas, 1907, publishes a map of Bouvet in a small insert with its south polar charts. The position given, the coast outline, and appearance are those of Lindsay Island.

Did Captains Bouvet and Norris see Lindsay Island or some island that has never been seen again? They reported it, Captain Bouvet in 1739, and Captain Norris in 1825, and placed it in latitude 54° 00′ S to 54° 15′ S and in longitude 4° 30′ E to 5° 00′ E, or about 15 miles north and about 50 miles east of Lindsay. We know that this position is seriously in error, for Cook, Ross, and Moore searched unsuccessfully for this island while on their various Antarctic cruises.

After taking bearings of Lindsay Island and such views as the weather and clouds permitted, we stood east in the hope of sighting Bouvet Island. Unfortunately, drifting ice, though in small pieces, became so thick that we thought it best to change our course to the north to avoid delay in this locality. So disappeared our chance of sighting either Bouvet or Thompson Islands.

Shortly after leaving the vicinity of Lindsay Island, it was decided to stand northward toward the Crozet Islands, so as to cut the isogonic lines at a greater angle.

When within 30 miles of the southwest point of Kerguelen Island the weather became unfavorable for making the land, fog set in, and a gale began to blow, with a rapidly falling barometer. The vessel was immediately headed south to avoid outlying dangers, and when clear the course was set toward Heard Island. The season was advancing, and as a large area remained to be covered before our return to Port Lyttelton, a delay of a week or more in order to land at Kerguelen seemed unwarranted. This was February 6, and in the evening a copper box, tightly sealed, containing abstracts of all results to date, was set adrift on a float. The following was stamped on the copper box with steel dies: "Mail to the Carnegie Institution, Washington, D. C., U. S. A., from Yacht *Carnegie,* February 6, 1916." The float was set adrift at 8^h p. m. in latitude 50° 14ʹ.3 S, longitude 68° 19ʹ.2 E. The only sign of human kind seen during 4 months, except at South Georgia, was a corpse floating in the open sea, about halfway between Heard and Kerguelen islands, far from land. This was on February 7, at latitude 51° 12′ S, longitude 71° 26′ E.

On February 8 our course was set to the northward to intersect the *Carnegie's* track of 1911, and to determine the annual change of the magnetic elements. We made the first intersection in good time, but encountered head winds and later a calm, when

attempting to make the second crossing. With the aid of the engine, however, we were able to make the desired point.

The annual changes determined were as follows: 17′ in declination, increasing numerically west values, as opposed to 8′ shown on the charts; −2′ in inclination, increasing numerically southerly dip; and −0.0007 C. G. S. in horizontal intensity, the value of this element decreasing.

The brief rest in quiet seas and in warm sunshine was very welcome, but the season was advancing and we were obliged to turn southward again and plunge into the dark and stormy regions of the "roaring forties and furious fifties." The stormiest period of the trip awaited us. The heaviest gale and roughest seas yet encountered were experienced, but the vessel stood the strain well.

As the *Carnegie* proceeded south toward the region of Queen Mary Land, the chart errors in declination constantly increased until, in the region of latitude 60° S, longitude 110° E, they reached a maximum of −12° for the United States and British charts, and of −16° for the German chart, *i. e.*, the charts gave values of west declination numerically too small by 12° to 16°.

On March 23, during magnetic observations in the afternoon, the horizontal intensity ranged from 0.098 to 0.110 C. G. S., possibly indicating a magnetic disturbance of some kind.

One iceberg was seen on March 1, the only one encountered since January 28. Owing to the decrease in horizontal intensity and the consequent uncertainty of the compasses, it was decided to turn to northward on this date, latitude 59° 24′ S having been reached. A few hours before turning northward a south wind sprang up, so it was well that we continued no farther in that direction.

The portion of our route extending into the Australian Bight was accomplished without special difficulty, and latitude 39° 29′ S was reached. Going south again, the *Carnegie* sailed as far as latitude 57° 25′ S, obtaining the low horizontal intensity of 0.086 C. G. S.

Owing to conditions of weather and lateness of season, it was thought best to head directly for Port Lyttelton, considering that we would intersect at good angles all isomagnetic lines.

The Snares were sighted early on the morning of March 29. They were almost exactly where we expected to see them, so we knew that our chronometers were giving us nearly correct longitudes, after 4 months of hard usage and with the wide range in temperature obtained in the cabin on account of the presence of the heating stove.

Observations for intensity and inclination were taken every day regardless of conditions, even when the vessel was hove to in a hurricane and was being tossed about like a chip, and mountainous seas were threatening to break through the observing domes. Magnetic declinations were observed on all but one day, during the four months' cruise—a remarkable record, considering the prevailing conditions of fog, mist, rain, and snow. This record was made possible only by the constant watchfulness of the entire party and by taking advantage of every opportunity. Considerable time was spent in "standing by," waiting for a break in the clouds or fog. Frequently only a small opening in the clouds would be seen approaching the Sun; then the vessel would be directed to the proper heading and all observers would be called to their stations ready to begin observations the moment the Sun appeared. Often the Sun was not seen again during the day.

I can not speak too highly of the work done by each and every member of the party, as to spirit of cooperation and unfaltering zeal in the face of most trying conditions.

Gales occurred of force 7 or higher, Beaufort scale, on 52 out of 120 days. On 26 days the gales were very strong, having an estimated force of 9 to 11. We were over-

taken by a continual procession of circular storms, moving about the south polar continent from west to east, and were invariably caught in the northern semicircle, as indicated by the barometer changes. A falling barometer always presaged northerly winds shifting to the northwest and blowing hard. As the barometer began to rise, the wind shifted to southwest, blowing a strong gale if the barometer rose rapidly. The temperature of the sea-water was taken every hour during the entire cruise, excepting the first few days. The air temperature averaged about 5° C. We had precipitation of some sort, mist, light rain, fog, rain, hail, or snow on 100 days out of the 120 days of the voyage. Fog was recorded on 20 days and snow on 16 days.

We were in the region where icebergs may be encountered for a period of 3.5 months, yet saw them on only 24 days, and to the number of only 133, the largest being 5 miles long and the highest being 500 feet high.

Upon the return to Port Lyttelton (April 1), there still remained two tanks of fresh water on board, and potatoes and onions sufficient for 3 more weeks.

The vessel sustained no serious damage during the trip. The metal fastening of the upper topsail yard broke on January 4, but the yard was successfully lashed to the parral and gave us no further trouble. The bronze bob-stay carried away at the forward end on February 24. It was fished up after some difficulty and secured with a deadeye and lanyard. Upon examination in the dry dock, the vessel's hull was found absolutely clean and undamaged, only one sheet of copper near the keel requiring renewal.

The total distance run from Lyttelton to Lyttelton was 17,084 miles, giving an average of 145 miles for 118 days. The entire track followed is shown in Plate 9 and also Figure 1.

ABSTRACTS OF LOGS OF THE CARNEGIE.

In the following abstracts of logs of the *Carnegie*, the data relating to the day's run and to the ocean current refer to the 24-hour period, noon to noon, preceding the noon position of the day for which the data is given, whereas it was more convenient to give the meteorological data, appearing in the column headed "Remarks," for the 24-hour period, midnight to midnight, of the date for which the data are given.

Whenever the word *miles* is used, throughout this publication, a *nautical mile* is the unit understood, unless otherwise indicated.

In the column headed "Current" is given the true direction toward which the ocean current was flowing, and the speed of the current in nautical miles per day.

J. P. AULT: ABSTRACT OF LOG, CRUISE IV, 1915–1917.

BROOKLYN TO CRISTOBAL, CANAL ZONE.

Date	Noon position: Lat.	Noon position: Long. E. of Gr.	Day's run	Current: Dir.	Current: Am't	Remarks
1915	° ′	° ′	*miles*	°	*miles*	
Mar 6	Brooklyn	....	......	......	.....	Left Beard's Basin in tow at 8^h20^m a. m.; 10^h20^m p. m. anchored in Gardiners Bay.
7	Gardiners Bay	....	91	......	.....	Swung ship two helms. Strong NE breeze to calm. Cloudy.
8	Do.	....	......	......	.....	Swung ship four helms. Gentle breeze.
9	Do.	....	......	......	.....	At 9^h10^m a. m. under way in tow of tug. Fresh breeze. Clear.
10	37 07 N	288 22	235	82	14	Strong NW wind to moderate gale. Squally.
11	33 40 N	288 28	207	63	28	Moderate to strong gale. Heavy sea. Squally.
12	30 45 N	288 11	176	70	18	Moderating wind and sea. Partly cloudy.
13	27 52 N	288 46	175	6	8	Moderate wind and sea. Partly cloudy.
14	26 27 N	289 19	90	184	16	Gentle breeze to calm to fresh breeze. Smooth sea. Overcast, rain.
15	24 03 N	290 24	156	4	5	Strong to light breeze. Moderate sea. Cloudy, rain.
16	22 52 N	290 37	72	208	8	Light to moderate breeze. Moderate sea. Partly cloudy.
17	22 15 N	293 03	140	340	4	Moderate breeze. Moderate sea. Partly cloudy.
18	20 37 N	293 13	98	79	3	Gentle breeze. Moderate sea. Partly cloudy.
19	18 11 N	291 43	169	298	15	Moderate breeze. Moderate sea. Overcast. Through Mona Passage.
20	16 49 N	289 32	149	52	12	Gentle breeze. Smooth Sea. Clear.
21	15 13 N	287 12	164	358	3	Moderate breeze. Moderate sea. Clear.
22	13 29 N	284 37	180	333	6	Moderate breeze. Moderate sea. Cloudy.
23	12 05 N	282 32	149	244	17	Gentle breeze. Moderate sea. Overcast.
24	10 55 N	280 23	145	278	13	Moderate breeze. Moderate sea. Cloudy.
25	Cristobal[1]	....	91	342	7	Fresh breeze. Moderate sea. Rain squalls. At 3^h50^m a. m. anchored in Colon Bay.

Total distance, 2,487 miles. Time of passage, 16.4 days. Average day's run, 151.6 miles.

[1] The *Carnegie* left Cristobal in tow April 7, at 8^h25^m a. m., to pass through the Panama Canal, and arrived at Pedro Miguel at 4 p. m. Leaving Pedro Miguel the next morning at 7^h30^m, the vessel arrived at Balboa, April 8, at 10^h45^m a. m.

BALBOA, CANAL ZONE, TO HONOLULU.

Date	Lat.	Long. E. of Gr.	Day's run	Dir.	Am't	Remarks
1915	° ′	° ′	*miles*	°	*miles*	
Apr 12	Balboa...	....	......	......	.....	At 10 a. m. left Balboa.
13	6 30 N	279 56	151	195	23	Gentle breeze to calm. Smooth sea. Clear.
14	5 32 N	279 43	59	188	40	Light airs and calm. Smooth sea. Clear.
15	3 59 N	279 33	93	187	33	Light airs. Smooth sea. Partly cloudy. Swung ship.
16	2 36 N	278 08	119	153	13	Light breeze. Smooth sea. Partly cloudy.
17	2 09 N	276 17	114	232	23	Light breeze. Smooth sea. Partly cloudy.
18	2 26 N	273 43	155	315	16	Gentle breeze. Smooth sea. Clear.
19	2 10 N	271 53	111	251	12	Light breeze. Smooth sea. Partly cloudy.
20	2 10 N	269 32	141	260	8	Gentle breeze. Smooth sea. Partly cloudy.
21	2 58 N	267 12	147	318	21	Gentle breeze. Smooth sea. Partly cloudy.
22	3 42 N	264 33	165	304	20	Gentle breeze. Smooth sea. Cloudy, showers, lightning. Tide rips.
23	4 55 N	263 51	85	181	5	Light variable winds. Smooth sea. Cloudy, squally.
24	4 28 N	263 53	27	87	11	Light winds. Smooth sea. Partly cloudy, lightning.
25	3 49 N	264 38	59	246	7	Light variable winds. Smooth sea. Partly cloudy.
26	4 15 N	263 36	67	251	2	Light breeze to calm. Smooth sea. Cloudy, squally.

BALBOA, CANAL ZONE, TO HONOLULU—*Concluded.*

Date	Noon position: Lat.	Noon position: Long. E. of Gr.	Day's run	Current: Dir.	Current: Am't	Remarks
1915	° ′	° ′	*miles*	°	*miles*	
27	4 57 N	262 09	97	344	3	Gentle to light breeze. Smooth sea. Passing showers.
28	6 27 N	261 14	105	109	7	Gentle breeze. Smooth sea. Squalls, rain.
29	8 12 N	260 36	112	101	21	Gentle breeze to light airs. Smooth sea. Partly cloudy.
30	8 29 N	259 44	54	164	9	Light airs. Smooth sea. Partly cloudy, lightning.
May 1	8 39 N	257 53	110	206	25	Gentle breeze. Moderate sea. Partly cloudy.
2	9 51 N	255 20	167	322	18	Moderate breeze. Moderate sea. Partly cloudy.
3	10 19 N	253 33	109	40	14	Gentle breeze. Moderate sea. Partly cloudy, showers.
4	10 25 N	250 11	199	135	15	Moderate breeze. Moderate sea. Partly cloudy. Passed Clipperton Island at 7^h50^m a. m.
5	11 08 N	247 37	156	259	5	Moderate breeze. Moderate sea. Partly cloudy.
6	11 53 N	244 49	170	93	6	Moderate breeze. Moderate sea. Cloudy, showers.
7	12 46 N	241 51	182	162	6	Fresh breeze. Moderate sea. Cloudy, showers.
8	13 38 N	239 13	163	89	14	Moderate breeze. Moderate sea. Partly cloudy, showers.
9	14 42 N	235 54	203	85	10	Strong breeze. Rough sea. Partly cloudy.
May 10	15 50 N	232 41	198	162	9	Fresh breeze. Rough sea. Partly cloudy.
11	16 49 N	230 02	164	103	23	Moderate breeze. Rough sea. Showers.
12	17 28 N	227 06	173	127	21	Moderate breeze. Rough sea. Cloudy, showers.
13	18 10 N	223 57	184	124	24	Fresh breeze. Heavy sea. Partly cloudy, showers.
14	19 00 N	221 11	164	152	12	Moderate breeze. Long NE swell, rough sea. Partly cloudy, showers.
15	19 45 N	218 06	179	54	15	Moderate breeze. Moderate sea. Partly cloudy, showers.
16	19 54 N	215 29	148	93	14	Gentle breeze. Moderate sea. Cloudy, squally.
17	20 34 N	212 15	186	85	6	Fresh breeze. Moderate sea. Partly cloudy, showers.
18	20 53 N	209 19	166	88	15	Moderate breeze. Moderate sea. Squally, rain.
19	21 05 N	206 19	168	128	8	Moderate breeze. Moderate sea. Cloudy, showers.
20	21 23 N	203 19	168	17	9	Moderate breeze. Moderate sea. Partly cloudy, squally.
21	Honolulu		85	....		Moderate breeze. Moderate sea. Clear. At 9^h30^m a. m. made fast to Quarantine Wharf.

Total distance, 5,303 miles. Time of passage, 39 days. Average day's run, 136.0 miles.

HONOLULU TO DUTCH HARBOR, ALASKA.

Date	Lat.	Long. E. of Gr.	Day's run	Dir.	Am't	Remarks
1915	° ′	° ′	*miles*	°	*miles*	
Jun 29	Honolulu	....	....	....	.....	Swung ship off Pearl Harbor all day.
Jul 3	Do.	....	....	....	.....	2^h15^m p. m. left Honolulu. Swung ship off Pearl Harbor till sunset.
4	22 39 N	201 20	103	148	5	Light to fresh breeze. Moderately rough to high sea. Partly cloudy.
5	25 40 N	199 47	200	174	12	Fresh breeze. Moderate sea. Partly cloudy.
6	28 03 N	198 54	150	207	8	Moderate breeze. Smooth sea. Partly cloudy, squally.
7	29 49 N	198 44	107	192	15	Light breeze. Smooth sea. Partly cloudy. Tide rips.
8	31 22 N	198 36	93	171	16	Gentle breeze. Smooth sea. Partly cloudy.
9	33 45 N	198 35	143	148	26	Moderate to strong breeze. Rough SW sea. Overcast.
10	36 24 N	199 01	160	142	25	Moderate breeze. Rough SW sea. Cloudy, rain.
11	37 31 N	196 10	154	164	24	Moderate breeze. Moderate sea. Cloudy, rain. Streams of barnacle clusters.
12	38 58 N	193 22	158	145	17	Moderate breeze. Moderate sea. Squally, overcast. Streams of barnacle clusters.
13	40 20 N	190 42	149	121	13	Gentle breeze. Moderate sea. Overcast. Streams of barnacle clusters and of velella.
14	40 51 N	189 28	64	146	18	Light breeze to calm. Smooth sea. Overcast, misty. Sea covered with velella. 10^h25^m a. m. started engine.
15	42 20 N	189 41	90	185	15	Calm. Smooth sea. Cloudy. Sea covered with velella. 2 p. m. stopped engine.
16	43 24 N	189 42	64	311	7	Calm to moderate breeze. Smooth sea. Overcast.
17	46 06 N	190 11	163	171	13	Fresh breeze. Moderate sea. Overcast, rain.
18	49 23 N	190 29	197	172	16	Fresh breeze. Rough sea. Overcast, rain.
19	52 36 N	190 18	193	209	14	Fresh to moderate breeze. Moderate sea. Cloudy, rain.
20	Dutch Harbor		138	....		Moderate breeze to calm. Moderate sea. Cloudy. Started engine 4^h30^m a. m. and ran to anchorage in Dutch Harbor at 12^h40^m p. m.

Total distance, 2,326 miles. Time of passage, 16.9 days. Average day's run, 137.6 miles.

DUTCH HARBOR TO PORT LYTTELTON, NEW ZEALAND.

Date		Noon position Lat.	Noon position Long. E. of Gr.	Day's run	Current Dir.	Current Am't	Remarks
1915		° ′	° ′	*miles*	°	*miles*	
Aug	5	Dutch Harbor					Left Dutch Harbor at 11h18m a. m. Strong breeze. Smooth sea. Rain.
	6	56 16 N	192 16	150	170	13	Fresh to moderate breeze. Moderate sea. Overcast.
	7	57 22 N	193 11	73	200	3	Calm to moderate breeze. Smooth sea. Overcast.
	8	58 02 N	192 25	47	222	4	Moderate gale to calm. High, choppy sea. Overcast.
	9	57 54 N	190 27	63	187	12	Light air to moderate gale. Moderate, choppy sea. Cloudy, misty.
	10	59 07 N	187 44	112	159	14	Moderate gale to light breeze. Moderate sea. Overcast, rain.
	11	59 32 N	186 52	36	169	9	Calm to moderate gale. Rough sea. Rain, overcast. St. Matthew Island in sight all day.
	12	58 47 N	182 58	128	133	13	Fresh breeze. Rough sea. Overcast.
	13	57 11 N	179 12	154	94	19	Moderate breeze. Smooth sea. Clear to overcast. Crossed 180th meridian.
	15	56 36 N	177 05	78	86	4	Moderate breeze. Smooth sea. Overcast to clear. Swung ship all day.
	16	55 35 N	175 16	86	115	8	Moderate breeze to calm. Smooth sea. Clear. Under engine power.
	17	53 57 N	172 13	144	46	15	Fresh breeze to moderate gale. Moderately heavy sea. Partly cloudy.
	18	51 49 N	169 51	155	3	10	Moderate gale to strong breeze. Heavy sea. Misty, rain.
	19	51 16 N	168 28	97	8	10	Gentle breeze. Heavy sea. Fog, rain.
	20	49 24 N	168 18	112	16	10	Moderate breeze. Moderate sea. Misty, rain, thunder.
	21	48 14 N	168 22	69	101	9	Light breeze. NW swell. Cloudy, lightning.
	22	46 53 N	166 11	120	11	8	Moderate breeze. Smooth sea. Overcast.
	23	45 25 N	164 20	117	76	16	Moderate breeze. Smooth sea. Overcast, rain.
	24	44 50 N	163 03	65	47	8	Light breeze. Smooth sea. Cloudy.
	25	44 37 N	163 18	17	359	11	Gentle breeze. Moderate sea. Partly cloudy, lightning.
	26	41 42 N	163 27	175	333	22	Fresh breeze. Rough sea. Overcast, rain.
	27	38 54 N	164 02	170	6	15	Moderate breeze. Moderate sea. Partly cloudy.
	28	36 35 N	164 49	144	73	33	Moderate breeze. Moderate sea. Clear.
	29	35 00 N	167 24	157	20	13	Moderate breeze. Moderate sea. Partly cloudy.
	30	33 50 N	170 05	151	353	29	Fresh breeze. S swell. Partly cloudy.
	31	31 52 N	170 56	125	11	12	Gentle breeze. Moderate sea. Cloudy.
Sep	1	30 06 N	171 08	107	177	24	Gentle breeze to calm. Smooth sea. Partly cloudy.
	2	29 08 N	170 39	63	183	14	Light airs. Smooth sea. Partly cloudy.
	3	28 21 N	170 06	55	222	9	Calm to gentle breeze. Smooth sea. Partly cloudy.
	4	26 10 N	168 57	145	3	25	Fresh breeze. Moderate sea. Cloudy.
	5	22 36 N	167 15	234	329	27	Strong breeze. Choppy sea. Squally.
	6	20 22 N	167 01	134	28	3	Wind increased to whole gale. Heavy sea. Squally, rain.
	7	21 28 N	169 16	142	128	4	Whole gale to gentle breeze. High sea. Squally, rain, lightning. Hove to.
	8	21 19 N	169 26	14	314	3	Moderate breeze. Moderate sea. Cloudy.
	9	21 01 N	168 31	55	225	1	Becalmed. Moderate swell. Cloudy, squally, lightning.
	10	20 39 N	168 09	30	257	8	Light airs. Long swell. Cloudy.
	11	19 56 N	167 20	64	283	13	Gentle breeze. Heavy swell. Partly cloudy, lightning.
	12	18 52 N	166 15	89	329	7	Gentle breeze. Moderate sea. Clear. Sighted Wake Island.
	13	17 00 N	165 24	122	331	20	Moderate breeze. Moderate sea. Partly cloudy, squally.
	14	15 18 N	165 18	103	124	3	Gentle breeze. Smooth sea. Overcast, rain, lightning.
	15	14 15 N	164 53	67	1	10	Light airs. Smooth sea. Cloudy, squally.
	16	13 52 N	166 02	70	341	15	Fresh wind to calm. Smooth sea. Cloudy, lightning.
	17	13 35 N	166 14	22	101	2	Calm to moderate breeze. Smooth sea. Partly cloudy.
	18	12 10 N	164 41	124	313	20	Calm to moderate breeze. Smooth sea. Partly cloudy.
	19	11 17 N	164 16	59	262	13	Light air. Smooth sea. Clear.
	20	10 12 N	164 03	66	228	16	Gentle breeze. Smooth sea. Partly cloudy.
	21	8 55 N	163 36	81	322	23	Moderate breeze. Smooth sea. Clear.
	22	8 03 N	163 39	53	23	20	Moderate breeze to calm. SE swell. Squally, overcast.
	23	7 01 N	164 10	69	134	7	Gentle breeze. Smooth sea. Partly cloudy, lightning.
	24	5 22 N	164 42	105	141	11	Gentle breeze. Smooth sea. Partly cloudy.
	25	4 18 N	164 01	76	258	15	Variable light airs. Smooth sea. Clear.
	26	3 58 N	163 54	21	254	19	Light airs and variable winds. Smooth sea. Squally.
	27	3 40 N	163 52	18	305	29	Calm and variable winds. Smooth sea. Cloudy.
	28	3 23 N	163 03	51	355	23	Gentle breeze. Smooth sea. Partly cloudy.
	29	3 07 N	162 07	59	341	24	Light airs. Smooth sea. Partly cloudy, lightning.
	30	2 23 N	161 40	52	300	31	Light airs. Smooth sea. Partly cloudy, lightning, thunder.
Oct	1	1 57 N	160 37	67	297	42	Moderate breeze. Smooth sea. Partly cloudy. Under engine power.
	2	0 25 N	159 53	102	307	43	Moderate breeze. Smooth sea. Clear.
	3	2 06 S	159 54	151	292	38	Fresh breeze. SE swell. Partly cloudy, lightning.
	4	4 12 S	161 09	147	259	31	Moderate breeze. SE swell. Partly cloudy, lightning.
	5	5 07 S	162 09	81	215	4	Gentle breeze. SE swell. Squally, rain. Under engine power.
	6	5 48 S	163 26	86	113	11	Light air. Smooth sea. Cloudy, lightning. Under engine power.
	7	6 21 S	163 56	45	58	21	Variable winds. Smooth sea. Squally, rain, lightning, and thunder.

DUTCH HARBOR TO PORT LYTTELTON—*Concluded.*

Date		Noon position Lat.	Long. E. of Gr.	Day's run	Current Dir.	Current Am't	Remarks
1915		° ′	° ′	*miles*	°	*miles*	
Oct	8	7 41 S	163 15	90	346	5	Gentle breeze. Smooth sea. Partly cloudy, lightning and thunder. Sighted Stewart Island from upper topsail yard.
	9	9 28 S	162 46	111	274	20	Gentle breeze. Moderate sea. Partly cloudy, lightning. Sighted Ulawa Island and a waterspout.
	10	10 23 S	162 43	55	215	8	Variable winds. Moderate sea. Squally, thunder and lightning in the morning. San Cristoval and Owa Riki Islands sighted.
	11	11 43 S	162 04	89	0	19	Fresh breeze. Moderate sea. Partly cloudy.
	12	12 52 S	160 45	104	334	19	Fresh breeze. Choppy sea. Partly cloudy. Breakers on Indispensable Reef sighted.
	13	13 58 S	159 48	86	226	6	Moderate breeze and calm. SE swell. Partly cloudy.
	14	16 22 S	158 24	166	351	19	Fresh breeze. Moderate sea. Partly cloudy.
	15	19 29 S	157 37	192	334	22	Fresh breeze. Moderate sea. Partly cloudy.
	16	21 42 S	157 19	134	16	11	Light breeze. Smooth sea. Clear.
	17	22 20 S	156 52	46	288	17	Light breeze. S swell. Partly cloudy.
	18	23 35 S	157 00	75	66	4	Moderate to light breeze. Smooth sea, S swell. Clear.
	19	24 23 S	156 26	58	281	15	Strong breeze. Choppy sea. Squally, overcast.
	20	26 09 S	155 15	127	331	22	Moderate breeze. Rough sea, SE swell. Partly cloudy.
	21	28 04 S	154 28	123	149	14	Gentle breeze. Smooth sea. Clear.
	22	30 10 S	155 27	135	278	7	Fresh breeze. Moderate sea. Partly cloudy.
	23	33 08 S	157 17	203	290	18	Strong breeze. Rough sea. Cloudy.
	24	35 36 S	158 17	155	352	23	Variable winds. Choppy sea. Cloudy.
	25	36 21 S	159 50	88	311	16	Variable winds and calm. SE swell. Cloudy, rain squalls.
	26	37 12 S	161 17	86	342	15	Moderate breeze. Cross swell. Partly cloudy, lightning.
	27	38 25 S	161 50	78	71	7	Moderate breeze. SW swell. Partly cloudy, squally, lightning and thunder.
	28	39 16 S	161 58	51	106	4	Light air to moderate breeze. Cross swell. Partly cloudy. Tide rips.
	29	41 51 S	162 33	157	29	19	Fresh breeze. NW swell. Overcast, rain.
	30	44 51 S	164 08	193	62	44	Moderate gale. Rough sea. Cloudy, squally.
	31	46 35 S	167 48	185	309	21	Strong breeze to light air. Rough sea. Overcast. In Foveaux Strait all day.
Nov	1	46 16 S	170 12	102	15	9	Gentle breeze. Smooth sea. Overcast. Under engine power. Aurora Australis.
	2	44 44 S	172 32	134	51	13	Gentle breeze. Smooth sea. Partly cloudy. Under engine power.
	3	Lyttelton.........		68	....		Gentle breeze. Smooth sea. Cloudy. At 10^h30^m a. m. alongside of dock, Lyttelton Harbor.

Total distance, 8,865 miles. Time of passage, 89 days. Average day's run, 99.6 miles.

PORT LYTTELTON TO SOUTH GEORGIA AND TO PORT LYTTELTON.

Date		Noon position Lat.	Long. E. of Gr.	Day's run	Current Dir.	Current Am't	Remarks
1915		° ′	° ′	*miles*	°	*miles*	
Dec	6	Lyttelton		....	....	.....	Left Port Lyttelton under tow at 11^h40^m a. m. Fresh breeze. Moderate sea. Cloudy.
	7	46 14 S	174 44	189	318	12	Moderate variable wind. Moderate sea. Overcast, drizzling. Mirage of land, 190 miles distant.
	8	47 47 S	176 23	115	344	16	Fresh breeze to strong gale. Heavy sea. Squally.
	9	49 10 S	178 41	123	3	15	Strong gale to strong breeze. Heavy sea. Squally. Crossed 180th meridian.
	9	50 11 S	181 42	132	321	8	Strong breeze to moderate gale. Heavy sea. Overcast, squally.
	10	51 15 S	184 01	107	343	14	Variable winds. Moderate sea. Overcast, misty.
	11	53 16 S	186 54	160	317	19	Moderate gale to gentle breeze. Heavy sea. Overcast, squally.
	12	53 54 S	188 53	81	44	15	Fresh variable winds. High sea. Overcast, damp.
	13	54 30 S	191 44	104	351	13	Fresh breeze. Moderate sea, SE swell. Cloudy, squally, hail.
	14	55 18 S	194 51	119	293	11	Fresh breeze. High sea. Cloudy, showers.
	15	56 00 S	197 38	103	326	14	Moderate variable winds. Moderate sea. Overcast, cloudy.
	16	57 10 S	201 58	159	209	24	Whole gale to strong breeze. Rough sea. Rain. Hove to 5 hours.
	17	58 58 S	205 25	152	326	16	Fresh breeze. High sea. Overcast, misty.
	18	60 18 S	208 50	132	307	16	Moderate variable winds. Moderate sea. Overcast, misty, snow. Iceberg.
	19	60 19 S	214 18	163	259	18	Strong breeze. High sea. Misty, snow. Icebergs.
	20	60 30 S	220 26	182	232	15	Fresh breeze. Moderate sea. Misty, snow. Icebergs.
	21	60 14 S	226 31	181	219	27	Fresh breeze to fresh gale. High sea. Misty, snow. Icebergs.
	22	59 40 S	232 08	172	202	22	Gentle breezes. Moderate sea. Overcast, drizzling. Icebergs.
	23	60 43 S	236 25	142	165	14	Fresh breeze. Rough sea. Rain, mist, fog. Iceberg.
	24	59 59 S	236 03	45	95	13	Calm, moderate gale. High sea, northerly swell. Fog, overcast. Iceberg.

PORT LYTTELTON TO SOUTH GEORGIA AND TO PORT LYTTELTON—*Continued.*

Date	Noon position Lat.	Long. E. of Gr.	Day's run	Current Dir.	Am't	Remarks
1915	° ′	° ′	*miles*	°	*miles*	
Dec 25	59 12 S	242 17	195	297	8	Moderate gale. High sea. Overcast, rain.
26	59 07 S	249 20	217	248	23	Strong breeze. High sea. Drizzling.
27	59 10 S	256 31	221	215	24	Strong breeze to moderate gale. High sea. Overcast, squally.
28	58 48 S	262 52	196	225	21	Fresh breeze. Moderate sea. Squally, partly cloudy.
29	58 47 S	268 30	175	271	12	Moderate breeze. Moderate sea, southerly swell. Overcast, rain, partly cloudy.
30	58 49 S	271 33	95	269	6	Light breeze. NW swell. Cloudy.
31	58 56 S	274 15	84	211	10	Light air to moderate breeze. Moderate sea. Partly cloudy, clear.
1916						
Jan 1	59 17 S	279 59	178	251	13	Fresh breeze. Moderate sea. Cloudy, misty.
2	60 04 S	285 30	174	230	17	Fresh breeze. Moderate sea. Drizzle, fog, mist.
3	59 41 S	291 00	167	215	22	Moderate breeze. W swell. Partly cloudy.
4	60 09 S	294 45	115	99	34	Variable light winds. Smooth sea. Fog.
5	59 16 S	297 18	119	299	28	Moderate breeze. Moderate sea. Partly cloudy.
6	58 42 S	302 25	166	142	17	Moderate breeze to strong gale. Moderate to high sea. Cloudy, overcast, rain.
7	57 44 S	307 37	174	219	9	Strong gale to moderate breeze. Heavy sea. Partly cloudy.
8	56 26 S	312 47	185	201	14	Fresh breeze to calm. Moderate sea. Overcast, cloudy. Under engine power.
9	55 32 S	315 22	104	243	7	Gentle breeze. Smooth sea. Overcast. Under engine power.
10	54 24 S	318 53	138	200	13	Gentle breeze. Smooth sea. Overcast, drizzle, fog. Icebergs. Hove to at night.
11	54 04 S	321 30	94	139	10	Gentle breeze. NW swell. Fog, mist. Icebergs. Under engine power. Sighted South Georgia.
12	54 08 S	323 30	82	312	8	Light breeze. Smooth sea. Misty, foggy. 9^h40^m a. m. anchored at King Edward Cove, South Georgia. Took on water.
14	King Edward Cove	. . . . . .	. . . .	. . . .	. . . .	7^h30^m p. m. left King Edward Cove under tow. Strong gale. Heavy sea. Squally.
15	54 16 S	327 11	134	268	5	Strong gale to light breeze. High sea. Cloudy. Icebergs.
16	54 40 S	331 35	155	181	6	Fresh breeze. Moderate to high sea. Rain, mist, fog. Icebergs. Hove to at night.
17	54 36 S	335 52	148	194	6	Moderate breeze to fresh gale. Moderate to high sea. Fog. Icebergs.
18	54 33 S	341 39	201	212	7	Fresh gale to light breeze. High to moderate sea, NW swell. Misty, fog. Icebergs.
19	54 30 S	344 52	112	237	12	Moderate breeze. Moderate sea. Overcast, drizzle, fog. Icebergs.
20	54 18 S	349 59	179	236	24	Fresh breeze. Moderate sea. Overcast, mist, fog. Icebergs.
21	54 20 S	356 35	232	227	29	Moderate gale. High sea. Overcast, fog. Icebergs.
22	54 00 S	1 41	180	181	15	Fresh breeze to strong gale. High sea. Partly cloudy, misty. Icebergs. Sighted Lindsay Island. Hove to at night.
23	53 33 S	5 33	140	232	7	Strong gale to moderate breeze. Moderate sea. Cloudy, misty. Icebergs.
24	53 42 S	9 49	152	241	17	Moderate breeze. Moderate sea. Overcast, fog, snow. Icebergs.
25	54 08 S	15 34	205	260	15	Fresh breeze. Moderate sea. Snow, partly cloudy. Icebergs.
26	54 30 S	21 18	202	225	15	Fresh breeze. Moderate sea. Overcast. Icebergs.
27	54 16 S	26 22	178	229	31	Strong to light breeze. Moderate sea. Fog, mist, snow. Icebergs.
28	53 40 S	30 57	165	198	22	Fresh breeze. Moderate sea. Overcast, snow. Iceberg.
29	52 40 S	36 39	214	202	26	Strong breeze to whole gale. High sea. Overcast, drizzling, snow. Hove to at night.
30	52 45 S	39 12	93	142	21	Whole gale to moderate gale. Heavy sea. Squally, rain. Hove to at night.
31	51 38 S	43 05	158	179	23	Moderate gale. Heavy sea. Overcast. Hove to at night.
Feb 1	49 42 S	47 15	196	19	19	Whole gale to strong wind. High sea. Squally, rain. Hove to at night.
2	48 36 S	50 59	160	179	12	Fresh breeze. Heavy swell. Partly cloudy.
3	48 33 S	55 13	168	301	22	Moderate breeze. Moderate sea. Partly cloudy.
4	48 40 S	59 57	188	275	16	Fresh breeze. Moderate sea. Overcast. Hove to at night.
5	49 01 S	63 44	151	344	14	Moderate breeze. Moderate sea. Overcast, drizzle, followed by clear weather.
6	49 34 S	67 12	139	314	8	Fresh breeze to moderate gale. High sea. Overcast, mist, drizzle. Set mail box adrift near Kerguelen Island. Hove to at night.
7	51 01 S	70 48	163	352	21	Moderate to whole gale. High sea. Cloudy, mist, squally. Hove to at night.
8	52 07 S	74 57	168	5	21	Strong gale to strong breeze. High sea. Squally, overcast, snow. Hove to at night.
9	51 04 S	77 52	125	314	13	Moderate gale to fresh breeze. Moderately rough sea. Cloudy.
10	49 47 S	80 29	127	237	17	Gentle variable winds to strong gale. Rough sea. Rain, mist.
11	47 10 S	83 39	201	247	24	Fresh gale. High sea. Squally, drizzle.

PORT LYTTELTON TO SOUTH GEORGIA AND TO PORT LYTTELTON—*Concluded.*

Date		Noon position Lat.	Long. E. of Gr.	Day's run	Current Dir.	Am't	Remarks
1916		° ′	° ′	*miles*	°	*miles*	
Feb	12	44 06 S	86 30	219	230	17	Fresh gale. High sea. Squally.
	13	41 15 S	88 32	195	203	28	Strong winds. Rough sea. Squally, overcast.
	14	38 18 S	90 26	197	198	24	Strong wind. Moderate sea. Overcast.
	15	35 48 S	93 10	198	189	23	Moderate wind. Smooth sea. Cloudy.
	16	34 32 S	95 58	157	265	27	Moderate breeze. Smooth sea. Clear.
	17	34 59 S	95 34	99	301	8	Gentle breeze. Southerly swell. Overcast.
	18	36 10 S	95 23	71	358	8	Light breeze to calm. Smooth sea. Overcast. Under engine power.
	19	36 08 S	97 09	85	243	10	Calm. Smooth sea. Overcast. Under engine power.
	20	37 26 S	97 30	80	315	9	Gentle breeze. Smooth sea. Overcast.
	21	39 48 S	99 11	162	350	21	Moderate gale. Moderate sea, SW swell. Partly cloudy, squally.
	22	42 18 S	100 26	160	35	25	Strong wind. Rough sea. Overcast.
	23	46 07 S	101 33	233	63	42	Fresh gale to modern breeze. Rough sea. Mist, drizzle.
	24	47 52 S	102 01	107	59	31	Gentle breeze to calm. W swell. Overcast. Bronze bobstay carried away.
	25	47 49 S	103 39	66	354	6	Moderate breeze. Moderately smooth sea. Cloudy.
	26	49 58 S	104 51	137	26	29	Fresh breeze to strong gale. Rough sea. Squally, drizzle.
	27	52 32 S	106 34	168	22	30	Whole gale. High sea. Squally, drizzle, hail. Hove to at night.
	28	54 33 S	107 33	126	46	25	Strong breeze. Rough sea. Mist, drizzle. Aurora australis.
	29	57 08 S	108 29	158	177	23	Strong gale. Rough sea. Squally, snow. Aurora australis.
Mar	1	59 15 S	110 00	136	30	20	Moderate gale. Rough sea. Snow, squally, cloudy. Iceberg. Hove to at night.
	2	56 54 S	112 23	161	267	23	Moderate gale. High sea. Partly cloudy, squally, snow.
	3	53 45 S	113 41	193	172	15	Fresh breeze. Moderate sea. Overcast. Aurora australis.
	4	51 30 S	116 26	169	198	16	Fresh variable winds. Moderate sea. Overcast, mist, drizzle. Aurora australis.
	5	49 13 S	120 16	201	136	33	Fresh gale. High sea. Squally, drizzle, hail.
	6	46 02 S	122 55	219	145	16	Fresh to whole gale. High sea. Squally, rain, hail. Hove to at night. Aurora australis.
	7	45 09 S	125 08	107	19	8	Storm to strong gale. High sea. Squally, rain, lightning. Hove to all day with drift anchor.
	8	44 58 S	126 01	39	0	7	Strong gale. High sea. Squally, cloudy, hail, rain, lightning. Hove to all day with drift anchor.
	9	44 11 S	126 34	53	349	12	Moderate gale. High sea. Squally, rain. Aurora australis.
	10	41 51 S	127 48	149	179	12	Fresh gale to strong breeze. High sea. Squally, drizzle.
	11	39 54 S	129 14	135	188	14	Fresh to light breeze. Moderate sea. Squally, overcast.
	12	40 25 S	130 03	49	160	11	Moderate breeze. Moderate sea. Partly cloudy, squally.
	13	43 04 S	131 01	165	175	19	Fresh breeze. SW swell. Partly cloudy.
	14	46 28 S	130 51	205	125	27	Fresh breeze to moderate gale. High sea. Squally, rain.
	15	48 42 S	132 52	156	172	21	Fresh breeze to moderate gale. Moderate sea. Squally, cloudy. Passing kelp.
	16	50 27 S	132 55	106	122	18	Moderate breeze. Moderate sea. Overcast, mist, fog. Swung ship six points. Aurora australis.
	17	53 44 S	131 51	200	115	29	Strong breeze to strong gale. High sea. Cloudy, squally, rain.
	18	56 35 S	133 05	176	141	30	Whole gale. Rough sea. Squally, hail. drizzle. Hove to. Bright aurora australis.
	19	56 48 S	135 36	84	83	25	Whole gale to moderate breeze. High sea. Squally. Brilliant aurora australis.
	20	57 09 S	138 37	102	238	12	Moderate breeze. NW swell. Clear to overcast. Penguins.
	21	56 53 S	143 00	144	229	12	Moderate breeze. Smooth sea. Overcast, mist, fog.
	22	56 47 S	144 47	59	263	17	Moderate variable breeze. NE swell. Overcast, fog, mist. Aurora australis.
	23	56 39 S	147 07	77	159	5	Moderate variable breeze. W swell. Overcast, fog, mist.
	24	54 24 S	151 00	190	134	5	Fresh breeze. High sea. Cloudy, rain.
	25	52 54 S	154 22	150	190	11	Moderate to light breeze. W swell. Overcast.
	26	52 37 S	156 35	82	77	8	Gentle variable winds. Moderate sea. Overcast, drizzle.
	27	50 59 S	160 47	184	252	19	Strong breeze to moderate gale. Rough sea. Cloudy.
	28	48 31 S	164 06	196	250	6	Moderate breeze. Moderate sea. Overcast.
	29	47 52 S	167 47	153	302	14	Moderate breeze. Moderate sea. Overcast. Sighted Snares and Stewart Islands.
	30	46 08 S	171 04	170	214	15	Moderate breeze. Smooth sea. Cloudy, overcast.
	31	44 49 S	172 51	109	113	8	Light breeze. Smooth sea. Overcast to partly cloudy. Under engine power.
Apr	1	Lyttelton		73	....		Light breeze. Smooth sea. Cloudy. Docked at Lyttelton at 10^h25^m a. m.

Total distance, 17,084 miles. Time of passage, 118 days. Average day's run, 144.8 miles.

PORT LYTTELTON TO PAGO PAGO, SAMOA.

Date		Noon position Lat.	Noon position Long. E. of Gr.	Day's run	Current Dir.	Current Am't	Remarks
1916		° ′	° ′	*miles*	°	*miles*	
May	17	Lyttelton	...	...	...	...	Left Lyttelton under tow at 1^h10^m p. m. Gentle breeze. Moderate sea. Clear.
	18	43 51 S	174 34	84	107	12	Light variable winds. Moderate sea. Partly cloudy. Under engine power.
	19	42 54 S	174 13	58	202	14	Gentle breeze. Easterly swell. Cloudy, misty, fog.
	20	43 41 S	176 06	94	243	19	Strong breeze to light air. Moderate sea. Partly cloudy, fog.
	21	43 58 S	176 44	32	147	7	Light airs and calm. Easterly swell. Partly cloudy, fog.
	22	44 03 S	178 26	74	97	25	Calm to strong winds. NE swell. Clear. Crossed 180th meridian.
	22	43 38 S	181 51	150	212	13	Fresh breeze. NE swell. Clear.
	23	41 16 S	184 21	185	196	18	Strong to light breeze. Moderate sea. Clear.
	24	39 49 S	185 46	108	177	10	Gentle to strong breeze. SW swell. Clear to overcast.
	25	36 44 S	186 36	189	212	18	Fresh breeze. Moderate sea. Partly cloudy.
	26	33 34 S	187 20	193	194	21	Moderate breeze. Moderate sea. Cloudy.
	27	30 46 S	185 28	192	183	17	Fresh breeze. NE swell. Cloudy, squally.
	28	30 59 S	186 15	42	195	13	Fresh gale to moderate breeze. NE swell. Overcast, lightning, thunder.
	29	30 32 S	187 53	89	169	11	Gentle breeze. Smooth sea. Squally, lightning and thunder.
	30	29 09 S	188 10	88	38	3	Fresh breeze to calm. Southerly swell. Overcast, drizzle.
	31	28 47 S	189 22	67	87	11	Calm to fresh breeze. Smooth sea. Partly cloudy, squally, lightning.
Jun	1	26 47 S	191 35	166	164	9	Strong to gentle breeze. Moderate sea. Squally, partly cloudy.
	2	24 42 S	191 39	125	128	16	Gentle breeze. Smooth sea. Overcast, squally.
	3	22 42 S	191 05	124	202	19	Gentle breeze to moderate gale. SSW swell. Overcast, rain.
	4	19 30 S	190 06	200	254	17	Moderate gale to moderate breeze. SE swell. Thunder, lightning, rain. Sighted Savage Island.
	5	18 33 S	189 06	81	252	15	Gentle breeze and calm. SE swell. Partly cloudy.
	6	16 18 S	189 31	136	205	6	Fresh variable winds. SE swell. Squally, lightning. Tide rips.
	7	Pago Pago	...	118	202	24	Fresh breeze. SE swell. Squally, rain, lightning. Started engine 6^h30^m a. m. Anchored at 2^h p. m. at buoy C.

Total distance, 2,595 miles. Time of passage, 22 days. Average day's run, 118.0 miles.

PAGO PAGO TO PORT APRA, GUAM.

Date		Noon position Lat.	Noon position Long. E. of Gr.	Day's run	Current Dir.	Current Am't	Remarks
1916		° ′	° ′	*miles*	°	*miles*	
Jun	19	Pago Pago	...	...	...	...	Left buoy under power at 11^h10^m a. m. Moderate breeze. Moderate sea. Partly cloudy, lightning.
	20	11 50 S	189 08	165	205	17	Fresh breeze. Easterly swell. Partly cloudy, lightning.
	21	9 14 S	189 24	157	299	13	Moderate breeze. Moderate sea. Partly cloudy, rain, lightning, thunder.
	22	6 32 S	188 50	165	257	11	Fresh breeze. Moderate sea. Partly cloudy, lightning.
	23	3 42 S	187 54	179	228	31	Moderate breeze. Moderate sea. Partly cloudy.
	24	1 26 S	186 55	149	227	38	Moderate to gentle breeze. Moderate sea. Partly cloudy.
	25	0 36 N	186 07	131	228	25	Gentle breeze. Smooth sea. Cloudy, squally, drizzling.
	26	2 14 N	184 34	134	157	18	Moderate breeze. Moderate sea. Partly cloudy.
	27	4 34 N	182 54	173	174	29	Fresh breeze. Moderate sea. Cloudy, squally, lightning.
	28	7 31 N	181 44	190	166	7	Fresh breeze. Moderate sea. Partly cloudy, squally.
	29	10 31 N	180 24	197	186	17	Fresh breeze. Moderate sea. Partly cloudy, squally rain. Crossed 180th meridian.
Jul	1	12 53 N	179 08	161	235	22	Moderate breeze. Moderate sea. Cloudy, squally.
	2	14 54 N	176 53	177	174	17	Moderate breeze. Moderate sea. Partly cloudy.
	3	15 44 N	174 20	156	159	8	Gentle breeze. Smooth sea. Squally, rain, lightning and thunder.
	4	16 20 N	172 11	129	166	19	Moderate breeze. Smooth sea. Partly cloudy, lightning and thunder.
	5	17 21 N	170 08	132	154	14	Moderate breeze. Smooth sea. Partly cloudy, lightning and thunder.
	6	18 15 N	167 30	161	95	8	Moderate breeze. Smooth sea. Partly cloudy, lightning.
	7	19 26 N	165 16	145	115	21	Moderate breeze. NE swell. Partly cloudy, lightning.
	8	20 20 N	163 03	136	142	8	Gentle breeze. Smooth sea. Squally, cloudy, lightning.
	9	20 26 N	161 10	106	39	5	Gentle breeze. SE swell. Partly cloudy, lightning.
	10	19 56 N	159 24	103	16	22	Gentle breeze. Smooth sea. Partly cloudy.
	11	19 20 N	157 38	106	56	21	Gentle breeze. SE swell. Partly cloudy.
	12	18 10 N	155 14	153	42	18	Moderate breeze. SE swell. Partly cloudy.
	13	17 03 N	152 54	150	28	14	Moderate breeze. ESE swell. Partly cloudy, lightning.
	14	15 56 N	150 37	148	38	22	Moderate breeze. Easterly swell. Partly cloudy, lightning.
	15	14 43 N	148 10	160	61	17	Moderate breeze. Easterly swell. Partly cloudy, squally, lightning.
	16	14 03 N	145 58	134	0	6	Gentle breeze. Smooth sea. Overcast, rain.
	17	Port Apra, Guam	...	90	356	12	Light breeze. Smooth sea. Overcast, heavy rain. Moored to buoy, 3^h15^m p. m.

Total distance, 3,987 miles. Time of passage, 27.2 days. Average day's run, 146.6 miles.

PORT APRA, GUAM, TO SAN FRANCISCO.

Date		Noon position		Day's run	Current		Remarks
		Lat.	Long. E. of Gr.		Dir.	Am't	
1916		° ′	° ′	miles	°	miles	
Aug	7	Port Apra, Guam					Left buoy at 1^h p. m. in tow. Fresh to strong breeze. SW swell. Heavy rain squalls.
	8	15 10 N	144 17	107	176	17	Moderate gale. Heavy swell. Squally, rain, lightning, thunder.
	9	16 45 N	144 11	95	88	19	Fresh gale. Heavy swell. Squally, rain. Hove to.
	10	17 21 N	144 28	40	89	19	Fresh gale. Heavy swell. Squally, rain. Hove to.
	11	17 54 N	144 27	32	134	9	Moderate gale to fresh breeze. WSW swell. Squally, rain, lightning.
	12	19 50 N	143 35	126	106	23	Fresh gale. Heavy sea. Overcast, squally, lightning.
	13	23 35 N	144 29	231	124	36	Fresh gale. Heavy sea. Squally, rain.
	14	27 03 N	144 25	208	163	26	Fresh breeze. SSW swell. Cloudy.
	15	30 08 N	143 59	185	114	22	Strong to light breeze. SW swell. Overcast, drizzling.
	16	30 18 N	144 20	20	100	12	Calm to gentle breeze. W then E swell. Cloudy, lightning. Under engine power.
	17	31 58 N	143 40	106	251	13	Moderate breeze. Moderate sea. Overcast, drizzling, lightning, thunder.
	18	34 14 N	146 09	185	251	13	Strong breeze. High sea. Rain.
	19	36 26 N	150 30	251	341	16	Strong breeze to moderate gale. High sea. Squally, rain.
	20	38 38 N	154 05	215	356	8	Moderate breeze. Moderate sea. Overcast, drizzling.
	21	40 29 N	156 39	162	277	8	Gentle breeze. Westerly swell. Overcast.
	22	42 51 N	158 26	134	241	18	Moderate breeze. Moderate sea. Overcast.
	23	44 57 N	159 20	132	193	15	Gentle breeze. Smooth sea. Partly cloudy.
	24	46 24 N	160 26	99	204	3	Light air to calm. Smooth sea. Overcast. Under engine power.
	25	46 56 N	163 06	113	308	12	Light breeze. Smooth sea. Cloudy. Under engine power.
	26	47 08 N	165 22	93	306	7	Moderate breeze to calm. Westerly swell. Overcast, fog. Swinging ship under engine power for *H* and *I*.
	27	47 16 N	167 49	100	170	5	Light air. Smooth sea. Partly cloudy. Swinging ship for *D*, 5 headings, 1 helm.
	28	47 25 N	169 08	54	272	6	Light breeze. Smooth sea. Partly cloudy. Under engine power.
	29	47 39 N	171 22	92	275	10	Gentle breeze. Smooth sea. Overcast, rain.
	30	48 20 N	175 20	164	274	14	Fresh breeze. Smooth sea. Overcast, rain. Crossed 180th meridian.
	30	48 55 N	180 04	191	273	17	Gentle breeze. SW swell. Misty and foggy.
	31	49 30 N	182 20	95	274	12	Light breeze. Smooth sea, W swell. Overcast.
Sep	1	49 53 N	184 16	78	219	9	Light breeze. Smooth sea. Overcast, foggy. Passed kelp.
	2	50 59 N	187 28	139	275	13	Moderate breeze to moderate gale. Smooth to high sea. Overcast, rain.
	3	51 31 N	192 02	174	303	15	Fresh gale to moderate breeze. High sea. Overcast, misty, fog.
	4	51 57 N	196 07	154	237	17	Light breeze. WNW swell. Overcast.
	5	52 38 N	199 25	128	219	6	Moderate breeze. Moderate sea. Overcast.
	6	53 16 N	204 16	180	230	18	Moderate breeze. Moderate sea. Overcast, drizzling.
	7	52 55 N	208 32	155	332	13	Gentle breeze. Smooth sea. Misty, drizzling, fog.
	8	51 48 N	212 24	157	335	22	Strong breeze. High sea. Misty, foggy, rain.
	9	49 33 N	215 51	187	359	20	Moderate breeze. Moderate sea. Foggy, misty.
	10	47 14 N	218 44	179	350	77	Moderate breeze. Moderate sea. Foggy, misty.
	11	45 30 N	220 36	130	337	18	Moderate breeze. Westerly swell. Foggy, misty.
	12	43 21 N	221 43	134	307	22	Moderate breeze. Moderate sea. Overcast.
	13	41 18 N	221 44	123	348	11	Moderate breeze. NE swell. Overcast.
	14	40 56 N	221 46	23	224	7	Light air and calm. NE swell. Overcast.
	15	40 47 N	221 58	12	171	4	Calm to gentle breeze. NE swell. Overcast.
	16	40 40 N	224 54	134	316	15	Moderate breeze. Moderate sea. Overcast.
	17	40 08 N	228 50	182	310	14	Moderate breeze. SW swell. Overcast.
	18	39 28 N	230 44	97	314	13	Fresh breeze. Westerly swell. Overcast.
	19	38 37 N	234 09	165	272	41	Moderate breeze. NNW swell. Overcast, misty, fog.
	20	38 17 N	235 31	67	219	12	Light air. Smooth sea. Foggy, misty. Under engine power.
	21	San Francisco		109			Calm. Smooth sea. Misty, foggy. Anchored at Quarantine, 11^h30^m a. m.

Total distance, 5,937 miles. Time of passage, 45.9 days. Average day's run, 129.3 miles.

SAN FRANCISCO TO EASTER ISLAND.

Date		Lat.	Long. E. of Gr.	Day's run	Dir.	Am't	Remarks
1916		° ′	° ′	miles	°	miles	
Nov	1	San Francisco					Left wharf at 1^h45^m p. m. Moderate breeze. Westerly swell. Partly cloudy.
	2	35 53 N	236 43	130	58	12	Light breeze. Westerly swell. Partly cloudy.
	3	35 19 N	236 00	49	185	3	Light breeze. Westerly swell. Partly cloudy, overcast, squally.
	4	34 12 N	236 25	71	111	7	Light to moderate breeze. Westerly swell. Partly cloudy, squalls, rain.

SAN FRANCISCO TO EASTER ISLAND—*Concluded.*

Date		Noon position Lat.	Noon position Long. E. of Gr.	Day's run	Current Dir.	Current Am't	Remarks
1916		° ′	° ′	*miles*	°	*miles*	
Nov	5	31 39 N	237 08	157	22	14	Moderate breeze. Westerly swell. Partly cloudy.
	6	29 18 N	238 22	155	334	11	Moderate breeze. NW swell. Partly cloudy.
	7	26 43 N	240 02	178	305	16	Fresh breeze. NW swell. Overcast.
	8	23 40 N	241 48	207	285	19	Fresh breeze. NW swell. Overcast, partly cloudy.
	9	21 01 N	243 16	178	295	26	Fresh to light breeze. NW swell. Partly cloudy.
	10	20 05 N	243 46	62	233	7	Light air. NW swell. Cloudy.
	11	19 32 N	243 52	33	204	17	Calm to light air. NW swell. Partly cloudy.
	12	18 40 N	244 26	61	244	3	Gentle breeze. Smooth sea. Overcast, partly cloudy.
	13	16 46 N	244 38	115	354	16	Gentle breeze. Smooth sea. Overcast.
	14	14 59 N	244 55	108	8	23	Light breeze. NW swell. Overcast, partly cloudy.
	15	14 13 N	244 56	47	180	14	Calm to gentle breeze. NW swell. Partly cloudy. Under engine power.
	16	12 17 N	244 56	116	329	24	Gentle to fresh breeze. Moderate sea. Partly cloudy, lightning.
	17	9 35 N	246 23	184	315	39	Fresh to gentle breeze. Moderate sea. Overcast, thunder showers.
	18	8 51 N	246 32	45	0	27	Light variable winds. SE swell. Overcast, rain, lightning, thunder.
	19	8 56 N	247 15	43	63	32	Calm and light air. SE swell. Overcast, thunder showers. Under engine power.
	20	7 51 N	248 33	101	187	4	Light breeze. SE swell. Overcast, thunder showers. Under engine power.
	21	7 37 N	249 25	54	351	30	Calm to fresh breeze. SE swell. Overcast, squally, rain.
	22	7 33 N	250 30	66	30	20	Light breeze. SE swell. Overcast, drizzling.
	23	7 11 N	251 13	48	127	16	Light variable winds. SE swell. Overcast, squally, rain.
	24	7 01 N	251 03	14	39	13	Gentle breeze. SE swell. Overcast, cloudy.
	25	6 53 N	253 02	118	22	18	Gentle breeze to calm. SE swell. Partly cloudy, overcast, drizzling. Under engine power.
	26	6 11 N	253 25	48	68	29	Calm to fresh breeze. SE swell. Overcast, rain, squalls. Under engine power.
	27	5 26 N	251 51	104	61	24	Fresh breeze. SE swell. Overcast, drizzling, squalls.
	28	5 04 N	249 21	151	287	13	Moderate breeze. SE swell. Overcast, drizzling.
	29	4 05 N	247 06	146	5	17	Fresh breeze. SE swell. Overcast, partly cloudy.
	30	1 52 N	243 36	247	273	40	Fresh breeze. Moderate sea. Overcast, squalls, partly cloudy.
Dec	1	0 17 S	241 28	182	98	31	Gentle breeze. Smooth sea. Partly cloudy. Tide rips.
	2	1 23 S	240 45	79	287	23	Light air and breeze. SE swell. Partly cloudy.
	3	2 16 S	239 59	71	267	32	Calm to gentle breeze. SE swell. Partly cloudy.
	4	4 26 S	239 04	141	232	12	Gentle to strong breeze. SE swell. Partly cloudy.
	5	6 54 S	236 55	196	30	10	Fresh breeze. SE swell. Partly cloudy.
	6	9 41 S	235 00	203	330	17	Fresh breeze. SE swell. Partly cloudy.
	7	12 38 S	234 32	179	303	8	Fresh breeze. SE swell. Partly cloudy.
	8	15 48 S	234 12	191	353	7	Moderate breeze. SE swell. Partly cloudy, rain squalls.
	9	17 50 S	233 55	123	325	12	Moderate breeze. SE swell. Squalls, partly cloudy.
	10	20 16 S	233 19	150	86	1	Gentle breeze. Smooth sea. Partly cloudy.
	11	22 22 S	233 30	126	343	8	Moderate breeze and sea. Easterly swell. Partly cloudy.
	12	24 49 S	234 02	150	25	8	Moderate breeze and sea. Easterly swell. Partly cloudy.
	13	26 29 S	235 35	130	40	2	Gentle breeze. NE swell. Partly cloudy.
	14	27 20 S	236 43	79	223	2	Light breeze to calm. Southerly swell. Partly cloudy.
	15	27 53 S	237 26	51	137	17	Light air. Southerly swell. Partly cloudy.
	16	28 58 S	238 32	86	150	7	Gentle breeze. Southerly swell. Partly cloudy.
	17	30 30 S	240 20	132	9	14	Gentle to fresh breeze. Westerly swell. Partly cloudy, squally.
	18	31 49 S	242 48	150	343	8	Moderate breeze. Westerly swell. Overcast, drizzling, squalls.
	19	32 09 S	245 28	137	27	1	Variable winds. SW swell. Partly cloudy, rain.
	20	32 23 S	248 10	139	168	6	Variable winds. SW swell. Squalls, rain, cloudy.
	21	31 02 S	250 56	163	210	18	Moderate breeze to calm. SW swell. Partly cloudy.
	22	30 30 S	251 02	32	207	6	Calm to light breeze. Westerly swell. Partly cloudy.
	23	30 17 S	251 29	26	194	11	Light to strong breeze. NE swell. Partly cloudy.
	24	27 22 S	250 45	179	205	27	Strong breeze. NE swell. Partly cloudy.
	24	Easter Island.....		24	....		Dropped anchor in Cook Bay, $3^h 20^m$ p. m.

Total distance, 6,155 miles. Time of passage, 53.1 days. Average day's run, 115.9 miles.

EASTER ISLAND TO BUENOS AIRES.

Date		Noon position Lat.	Long. E. of Gr.	Day's run	Current Dir.	Am't	Remarks
1917		° ′	° ′	*miles*	°	*miles*	
Jan	2	Easter	Island.....	......	......	.....	Left anchorage in Cook Bay at 7h00m a. m.
	2	26 52 S	250 21	18	180	1	Gentle breeze. Smooth sea. Partly cloudy.
	3	24 18 S	249 03	170	173	24	Moderate to fresh breeze. Smooth sea. Overcast.
	4	21 24 S	248 50	174	186	22	Fresh breeze. NE swell. Cloudy, squalls.
	5	18 12 S	248 35	193	162	23	Fresh breeze. Easterly swell. Partly cloudy, squalls.
	6	15 04 S	248 54	189	170	24	Fresh breeze. Easterly swell. Partly cloudy.
	7	12 28 S	248 38	156	160	26	Fresh breeze. Easterly swell. Overcast, partly cloudy.
	8	12 30 S	245 51	163	97	10	Moderate breeze. Easterly swell. Partly cloudy.
	9	12 34 S	242 54	173	110	12	Moderate breeze. Easterly swell. Partly cloudy.
	10	12 36 S	239 42	188	98	15	Moderate breeze. Easterly swell. Partly cloudy.
	11	12 41 S	236 44	173	106	18	Moderate breeze. Easterly swell. cast, partly cloudy.
	12	14 33 S	234 23	176	39	15	Moderate breeze. Easterly swell. Partly cloudy, overcast, squalls.
	13	16 02 S	232 45	130	22	10	Gentle breeze. Easterly swell. Partly cloudy.
	14	17 27 S	231 22	116	59	15	Light breeze to moderate gale. Smooth sea. Partly cloudy, overcast, drizzling.
	15	19 35 S	230 04	148	102	17	Moderate gale to calm. NW swell. Overcast, squalls.
	16	19 42 S	229 45	18	254	14	Calm and light air. NW swell. Cloudy, lightning.
	17	20 10 S	229 04	48	216	5	Light air to gentle breeze. SE swell. Thunder showers.
	18	21 42 S	227 06	144	68	16	Moderate breeze. SE swell. Overcast, partly cloudy.
	19	23 26 S	225 03	154	19	26	Fresh breeze. SE swell. Partly cloudy. Passed Gambier Island.
	20	26 44 S	223 27	216	70	12	Fresh breeze. Moderate sea. Partly cloudy.
	21	29 35 S	221 06	212	59	27	Fresh breeze. SW swell. Partly cloudy.
	22	32 16 S	220 23	165	25	17	Moderate breeze and sea. Partly cloudy, overcast, rain.
	23	34 46 S	220 02	150	359	15	Gentle to strong breeze. SW swell. Overcast.
	24	37 21 S	218 05	181	67	8	Strong breeze to strong gale. Heavy sea. Overcast, drizzling. Hove to.
	25	37 35 S	217 09	46	315	4	Strong gale. Heavy sea. Overcast, misty, rain. Hove to.
	26	37 46 S	216 14	46	270	15	Strong to moderate gale. Heavy sea. Overcast, squalls. Hove to.
	27	37 52 S	215 38	29	269	15	Strong to light breeze. SE swell. Overcast, squalls.
	28	37 54 S	217 18	79	338	12	Gentle breeze. SE swell. Overcast, partly cloudy, misty.
	29	38 26 S	220 16	144	308	14	Moderate breeze to fresh gale to moderate breeze. Southerly swell. Overcast, squalls, partly cloudy.
	30	38 31 S	221 43	69	341	13	Moderate breeze to calm. Southerly swell. Partly cloudy.
	31	39 34 S	222 23	70	86	4	Light air to moderate breeze. SE swell. Partly cloudy.
Feb	1	41 58 S	222 02	145	352	17	Moderate breeze. Southerly swell. Partly cloudy.
	2	43 40 S	221 31	103	328	12	Light to fresh breeze. Southerly swell. Overcast.
	3	42 35 S	225 40	192	271	31	Fresh to light breeze. Southerly swell. Overcast, partly cloudy.
	4	43 09 S	228 38	135	300	25	Light to fresh breeze. Southerly swell. Overcast, partly cloudy.
	5	45 10 S	232 25	204	335	21	Strong breeze. Southerly swell. Overcast, squally, rain.
	6	46 27 S	236 43	195	305	22	Fresh breeze. Southerly swell. Overcast, squally.
	7	46 59 S	241 28	198	288	18	Moderate gale. Southerly swell. Overcast, squalls.
	8	48 58 S	244 09	160	344	19	Moderate gale. Heavy sea, southerly swell. Overcast, squalls.
	9	51 59 S	247 38	224	27	27	Moderate to fresh gale. High sea. Overcast, misty.
	10	54 05 S	252 12	209	330	24	Moderate gale to strong breeze. Rough sea. Overcast, misty.
	11	54 37 S	257 54	202	7	21	Strong breeze to moderate gale. Rough sea. Overcast, hail, squalls.
	12	55 17 S	264 35	234	323	20	Moderate gale. Heavy sea. Cloudy, squalls, hail.
	13	56 10 S	271 20	234	325	24	Fresh gale to strong breeze. Heavy sea. Cloudy, squalls, hail.
	14	56 52 S	277 23	205	328	22	Variable winds. Southwest swell. Overcast, squalls, drizzling, fog.
	15	57 38 S	283 22	200	331	6	Strong breeze. Westerly swell, rough sea. Overcast, rain, drizzling.
	16	56 42 S	289 55	220	195	19	Strong breeze to fresh gale to light breeze. Rough sea. Overcast, squalls. Passed Diego Ramires Island.
	17	55 58 S	293 50	137	176	7	Moderate breeze. SW swell. Overcast, rain, partly cloudy. Sighted Cape Horn.
	18	55 03 S	295 47	86	79	17	Calm to strong breeze. Rough sea. Partly cloudy, drizzling.
	19	53 29 S	296 52	102	27	20	Moderate breeze to light air to moderate gale. Rough sea. Cloudy, overcast.
	20	52 16 S	296 00	79	259	5	Variable winds. NE swell. Partly cloudy.
	21	50 08 S	298 36	161	153	9	Fresh breeze. Rough sea. Partly cloudy.
	22	47 55 S	300 01	144	26	7	Light variable winds and calm. Southerly swell. Partly cloudy.
	23	46 18 S	300 32	100	335	18	Calm and light air. Smooth sea. Partly cloudy, lightning. Under engine power.
	24	45 33 S	301 00	48	358	15	Calm and light air. Smooth sea. Overcast, foggy. Under engine power.

EASTER ISLAND TO BUENOS AIRES—*Concluded.*

Date	Noon position Lat.	Long. E. of Gr.	Day's run	Current Dir.	Am't	Remarks
1917	° ′	° ′	*miles*	°	*miles*	
Feb 25	43 34 S	301 41	122	335	17	Calm to strong breeze. Easterly swell, heavy sea. Overcast, drizzling, rain. Under engine power.
26	39 57 S	302 58	225	342	20	Strong to gentle breeze. Rough sea. Rain, mist.
27	38 13 S	304 04	116	10	5	Light variable winds and calm. SE swell. Partly cloudy, lightning and thunder, rain, hail.
28	37 09 S	304 31	68	27	28	Calm to fresh breeze. SE swell. Partly cloudy, lightning, rain.
Mar 1	35 07 S	303 24	133	72	16	Moderate variable winds. Smooth sea. Partly cloudy. Under engine power in the River Plate.
2	Buenos Aires......		100	.....	.....	Light breeze. Smooth sea. Clear. Docked at Buenos Aires at 10^h45^m a. m.

Total distance, 8,619 miles. Time of passage, 59.1 days. Average day's run, 145.8 miles.

TABLE 21.—*Summary of Passages for Cruise IV of the Carnegie.*

Passage	Length of passage	Time of passage	Average day's run
	miles	*days*	*miles*
Brooklyn to Cristobal, Canal Zone................	2,487	16.4	152
Cristobal to Balboa............................	42	0.5	....
Balboa to Honolulu............................	5,303	39.0	136
Honolulu to Dutch Harbor.......................	2,326	16.9	138
Dutch Harbor to Port Lyttelton..................	8,865	89.0	100
Port Lyttelton to Port Lyttelton.................	17,084	118.0	145
Port Lyttelton to Pago Pago....................	2,595	22.0	118
Pago Pago to Guam............................	3,987	27.2	147
Guam to San Francisco.........................	5,937	45.9	129
San Francisco to Easter Island..................	6,155	53.1	116
Easter Island to Buenos Aires...................	8,619	59.1	146

Length of Cruise IV, 63,400 miles. Time at sea, 487.1 days. Average day's run, 130 miles.

H. M. W. EDMONDS: ABSTRACT OF LOG, CRUISE V, 1917–1918.

BUENOS AIRES TO TALCAHUANO, CHILE.

Date	Noon position Lat.	Long. E. of Gr.	Day's run	Current Dir.	Am't	Remarks
1917	° ′	° ′	*miles*	°	*miles*	
Dec 4	Buenos Aires......		....	.....	.....	Left dock under tow at 11^h45^m a. m. Gentle breeze to moderate gale. Moderate sea. Partly cloudy. Anchored overnight.
5	34 44 S	302 27	42	.....	.....	Moderate to strong breeze. Moderate sea. Partly cloudy. Under engine power. Anchored overnight.
6	35 32 S	303 29	71	.....	.....	Gentle to moderate breeze. Rough sea. Partly cloudy. Under engine power.
7	35 47 S	304 07	67	.....	.....	Moderate breeze and sea. Partly cloudy.
8	37 50 S	305 02	131	26	14	Light variable winds. NE swell. Partly cloudy, drizzling, lightning.
9	39 21 S	304 59	92	30	36	Gentle to strong breeze. Moderate sea. Partly cloudy, lightning.
10	38 58 S	303 04	93	20	18	Strong breeze to calm. Moderate sea, SE swell. Partly cloudy.
11	40 04 S	302 23	73	67	7	Light variable winds. SE swell. Overcast, drizzling.
12	42 02 S	300 31	145	80	14	Moderate to strong breeze. Moderate sea. Partly cloudy, lightning.
13	43 26 S	299 11	103	36	16	Strong breeze to strong gale. Heavy sea. Partly cloudy, rain, lightning.

BUENOS AIRES TO TALCAHUANO, CHILE—*Concluded.*

Date	Noon position: Lat.	Noon position: Long. E. of Gr.	Day's run	Current: Dir.	Current: Am't	Remarks
1917	° ′	° ′	*miles*	°	*miles*	
Dec 14	43 06 S	298 51	25	35	41	Moderate gale to calm. SW swell. Partly cloudy.
15	44 35 S	297 28	107	43	12	Moderate to strong breeze. Moderate sea. Partly cloudy.
16	47 31 S	296 59	177	36	22	Moderate breeze and sea. Partly cloudy.
17	49 52 S	297 26	143	17	14	Moderate breeze to moderate gale. Rough sea. Partly cloudy.
18	51 29 S	297 52	98	18	14	Fresh to strong breeze. Rough sea. Squally, rain, hail.
19	53 07 S	299 59	125	273	10	Moderate gale. Rough sea. Partly cloudy, squalls, hail, snow.
20	53 09 S	300 28	18	33	14	Light to fresh breeze. S swell. Partly cloudy, squalls, hail. Sighted Beauchene Island.
21	53 33 S	299 38	38	93	20	Strong to gentle breeze. SE swell. Overcast, squalls. Under engine power.
22	54 58 S	297 07	123	60	21	Moderate breeze. SE swell. Cloudy, drizzling, rain.
23	56 07 S	295 40	84	93	24	Light breeze. Easterly swell. Partly cloudy, rain.
24	57 30 S	292 31	133	112	15	Moderate breeze to moderate gale. Rough sea. Partly cloudy, misty, rain.
25	58 49 S	288 25	152	116	21	Moderate gale to fresh breeze. Rough sea. Partly cloudy, squalls, drizzling.
26	58 17 S	285 44	90	131	8	Fresh breeze, calm to storm. Rough sea. Overcast, rain, hail. Hove to.
27	57 37 S	286 30	47	35	19	Whole gale to fresh breeze. Rough sea. Partly cloudy, squalls, hail. Hove to.
28	58 32 S	284 48	77	147	10	Fresh to gentle breeze. Westerly swell, rough sea. Partly cloudy, rain, squally.
29	59 10 S	284 22	40	162	17	Calm to moderate breeze. Westerly swell. Overcast. Under engine power.
30	58 32 S	281 06	108	62	16	Moderate breeze. Westerly swell. Partly cloudy, rain, squally.
31	55 55 S	279 45	163	134	14	Moderate to strong breeze. Moderate sea. Overcast, drizzling.
1918						
Jan 1	52 37 S	279 58	198	136	11	Strong breeze. Rough sea. Overcast, rain.
2	52 08 S	279 07	42	226	9	Strong breeze to strong gale. High sea. Overcast, misty.
3	52 02 S	279 08	6	89	8	Strong to moderate gale. Rough sea. Partly cloudy, squalls.
4	50 24 S	279 54	102	29	12	Moderate gale to fresh breeze. Rough sea. Cloudy, rain, squally.
5	47 38 S	279 23	168	51	4	Strong breeze. SW swell. Partly cloudy, hail.
6	44 42 S	280 21	180	77	9	Moderate breeze. SW swell. Partly cloudy, squally.
7	42 52 S	281 22	119	114	5	Light breeze. SW swell. Partly cloudy.
8	41 34 S	283 26	88	51	9	Light air to moderate breeze. Smooth sea. Overcast.
9	39 24 S	283 26	141	311	6	Moderate to strong breeze. Smooth sea. Overcast.
10	36 54 S	286 20	203	320	15	Strong to gentle breeze. Moderate sea. Clear.
11	Talcahuano		51	.....	.....	Light breeze. Southerly swell. Clear. Dropped anchor at 8^h42^m a. m.

Total distance, 3,863 miles. Time of passage, 37.9 days. Average day's run, 101.9 miles.

TALCAHUANO TO CALLAO, PERU.

Date	Lat.	Long. E. of Gr.	Day's run	Dir.	Am't	Remarks
1918	° ′	° ′	*miles*	°	*miles*	
Jan 23	Talcahuano	....	....	....	.....	Left anchorage at 9^h00^m a. m. Light to gentle breeze. SW swell. Partly cloudy, foggy.
24	35 18 S	286 03	97	212	7	Gentle to moderate breeze. SW swell. Partly cloudy.
25	33 03 S	284 52	147	179	8	Moderate breeze. SW swell. Partly cloudy.
26	31 25 S	284 09	104	111	6	Moderate to light breeze. SW swell. Partly cloudy.
27	30 47 S	283 35	48	51	5	Calm to moderate breeze. SW swell. Partly cloudy.
28	29 04 S	281 34	147	121	14	Moderate to fresh breeze. SW swell. Partly cloudy.
29	27 28 S	278 50	174	101	14	Strong breeze. SW swell. Partly cloudy.
30	28 07 S	275 33	178	44	10	Strong breeze. Rough sea. Overcast, squally. Topgallantmast carried away.
31	29 35 S	273 04	157	15	12	Fresh breeze. Rough head sea. Partly cloudy, squally.
Feb 1	31 29 S	271 20	145	13	10	Fresh breeze. Rough sea. Overcast.
2	33 07 S	269 16	144	11	12	Gentle to fresh breeze. Moderate sea. Overcast.
3	35 27 S	268 11	150	18	9	Moderate breeze. Smooth sea. Overcast.
4	36 55 S	268 45	92	176	8	Light breeze to light air. Smooth sea. Partly cloudy.
5	36 56 S	270 08	67	100	15	Gentle breeze. Smooth sea. Partly cloudy.

TALCAHUANO TO CALLAO, PERU—*Concluded.*

Date	Noon position Lat.	Noon position Long. E. of Gr.	Day's run	Current Dir.	Current Am't	Remarks
1918	° ′	° ′	*miles*	°	*miles*	
Feb 6	36 59 S	272 06	94	207	10	Light to moderate breeze. Smooth sea. Partly cloudy.
7	36 58 S	275 07	145	234	13	Moderate to fresh breeze. Smooth sea. Partly cloudy.
8	36 08 S	278 28	169	206	14	Fresh breeze. Smooth sea. Partly cloudy, drizzling.
9	34 12 S	278 43	117	186	7	Fresh breeze. SW swell. Misty, partly cloudy. Sighted Mas Afuera Islands.
10	31 58 S	278 36	134	199	19	Moderate to light breeze. SW swell. Partly cloudy.
11	30 16 S	278 24	102	255	10	Moderate breeze. SW swell. Partly cloudy.
12	28 04 S	278 11	133	236	14	Moderate breeze. SW swell. Overcast, partly cloudy.
13	25 39 S	278 12	144	219	13	Moderate to gentle breeze. SW swell. Overcast, partly cloudy.
14	23 58 S	278 31	102	297	14	Gentle breeze. Southerly swell. Overcast.
15	22 30 S	278 58	92	313	12	Gentle breeze. Southerly swell. Overcast.
16	20 53 S	279 47	107	328	13	Light breeze. Smooth sea. Overcast.
17	19 44 S	280 33	81	343	14	Light to gentle breeze. Smooth sea. Overcast.
18	18 18 S	281 40	107	331	5	Gentle breeze. Smooth sea. Partly cloudy.
19	16 25 S	281 52	113	309	12	Light breeze. Smooth sea. Overcast.
20	14 18 S	282 10	129	285	18	Gentle to light breeze. Smooth sea. Partly cloudy.
21	13 14 S	282 36	69	328	12	Light air. Smooth sea. Partly cloudy.
22	12 21 S	282 34	53	350	19	Light air. Smooth sea. Foggy, partly cloudy.
22	Callao........		27	....		Anchored at Callao 6^h10^m p. m.

Total distance, 3,568 miles. Time of passage, 30.4 days. Average day's run, 117.4 miles.

CALLAO TO BALBOA, CANAL ZONE.

Date	Lat.	Long. E. of Gr.	Day's run	Dir.	Am't	Remarks
1918	° ′	° ′	*miles*	°	*miles*	
Mar 29	Callao........					Left anchorage 9^h16^m a. m. Calm to light breeze. Southerly swell. Partly cloudy. Under engine power.
30	11 00 S	281 28	102	212	2	Light to gentle breeze. Southerly swell. Partly cloudy, foggy.
31	10 00 S	279 28	133	344	7	Gentle to moderate breeze. Southerly swell. Partly cloudy.
Apr 1	10 14 S	277 75	131	140	2	Moderate breeze. Southerly swell. Partly cloudy.
2	11 24 S	274 58	152	318	7	Moderate to gentle breeze. Southerly swell. Partly cloudy.
3	12 28 S	273 21	114	277	3	Gentle to strong breeze. Rough sea. Overcast, squalls, rain.
4	14 10 S	271 06	167	305	6	Fresh to strong breeze. Rough sea. Cloudy, squalls, rain.
5	15 59 S	268 52	170	272	6	Fresh breeze. Rough sea. Overcast.
6	16 09 S	266 19	147	359	13	Moderate to strong breeze. Southerly swell. Partly cloudy.
7	15 34 S	263 29	167	295	6	Strong to moderate breeze. SE swell. Partly cloudy.
8	13 43 S	264 12	119	304	10	Fresh to moderate breeze. Rough sea. Overcast, drizzling, squalls.
9	12 07 S	265 01	107	304	3	Gentle breeze. SE swell. Partly cloudy.
10	10 35 S	266 00	109	229	1	Moderate breeze. SE swell. Partly cloudy.
11	8 47 S	267 24	136	304	11	Moderate to fresh breeze. SE swell. Partly cloudy.
12	7 28 S	268 46	113	254	13	Fresh breeze. Rough sea. Cloudy.
13	6 22 S	270 01	100	239	22	Moderate to strong breeze. Rough sea. Overcast.
14	5 18 S	272 01	135	198	15	Strong to fresh breeze. Rough sea. Overcast, partly cloudy.
15	3 35 S	273 38	142	145	7	Fresh to gentle breeze. SE swell. Overcast, rain, squalls.
16	2 06 S	274 28	102	239	13	Gentle to light breeze. SE swell. Partly cloudy.
17	1 12 S	275 20	75	345	10	Light to gentle breeze. SE swell. Partly cloudy.
18	0 12 N	276 56	128	12	28	Gentle to moderate breeze. Smooth sea. Partly cloudy.
19	1 41 N	278 27	127	19	26	Gentle to light breeze. Smooth sea. Partly cloudy.
20	2 29 N	280 00	106	53	20	Light breeze to calm. Smooth sea. Cloudy, lightning.
21	3 29 N	280 42	73	56	23	Light to gentle breeze. Smooth sea. Partly cloudy.
22	5 12 N	281 27	113	57	16	Gentle breeze. Smooth sea. Overcast, rain, drizzle.
23	7 09 N	281 38	117	22	29	Gentle breeze to light air. SW swell. Overcast, rain. Under engine power.
24	8 26 N	280 27	104	324	36	Light breeze. SW swell. Overcast, rain. Under engine power.
24	Off Balboa.......		23	....		At 5^h05^m p. m. anchored off Taboguilla Island.
25	Balboa[1].....			....		Towed 14 miles from anchorage to dock at 5^h15^m p. m.

Total distance, 3,212 miles. Time of passage, 26.3 days. Average day's run, 122.1 miles.

[1] The *Carnegie* left Balboa under tow at 6^h23^m a. m., May 2, and arrived at Cristobal at 7^h45^m p. m. the same day.

CRISTOBAL TO NEWPORT NEWS.

Date	Noon position Lat.	Long. E. of Gr.	Day's run	Current Dir.	Am't	Remarks
1918	° ′	° ′	miles	°	miles	
May 11	Cristobal					Left Cristobal dock at 11^h55^m a. m. Light breeze to calm. N swell. Overcast, lightning, thunder.
12	10 17 N	280 26	65	49	28	Calm to moderate breeze to calm. NE swell. Overcast, squally, lightning. Under engine power.
13	11 45 N	280 24	88	7	37	Light air to fresh breeze. Rough sea. Partly cloudy, lightning.
14	13 31 N	280 13	106	314	16	Fresh to moderate breeze. Rough sea. Partly cloudy.
15	14 02 N	279 38	47	278	21	Gentle to moderate breeze. Moderate sea. Partly cloudy.
16	16 01 N	278 29	136	328	24	Moderate to gentle breeze. Smooth sea. Partly cloudy.
17	18 02 N	277 19	138	314	46	Gentle breeze. Smooth sea. Partly cloudy.
18	20 15 N	276 14	147	331	50	Gentle breeze. Smooth sea. Partly cloudy.
19	21 21 N	274 41	109	302	33	Gentle to moderate breeze. Smooth sea. Partly cloudy.
20	23 38 N	273 44	147	335	69	Moderate breeze. Smooth sea. Partly cloudy.
21	23 45 N	274 38	51	108	23	Moderate to fresh breeze. Rough sea. Partly cloudy.
22	23 20 N	276 16	93	78	36	Fresh breeze. Rough sea. Partly cloudy, lightning, thunder.
23	24 02 N	277 02	59	116	44	Fresh to strong breeze. Rough sea. Cloudy, squalls, rain, lightning, thunder.
24	23 48 N	278 08	62	57	28	Strong breeze to moderate gale. Rough sea. Cloudy, squalls, rain. Sighted American Shoal light.
25	24 16 N	279 10	63	57	57	Strong to fresh breeze. Rough sea. Overcast, rain. Sighted Alligator Reef light.
26	25 19 N	280 10	83	39	67	Fresh breeze. Moderate sea. Partly cloudy. Sighted Carysfort light.
27	28 58 N	280 09	219	355	75	Moderate to gentle breeze. Smooth sea. Partly cloudy.
28	30 39 N	281 00	110	352	48	Gentle breeze to light air. Smooth sea. Partly cloudy.
29	31 12 N	281 50	54	24	9	Light air to calm. Smooth sea. Partly cloudy.
30	31 50 N	282 17	45	354	21	Light breeze. Smooth sea. Partly cloudy.
31	32 44 N	284 01	103	118	10	Light to moderate breeze. Smooth sea. Partly cloudy.
Jun 1	33 54 N	284 34	105	44	8	Light breeze to calm. Westerly swell. Partly cloudy.
2	34 29 N	285 59	40	79	23	Light to moderate breeze. Moderate sea. Partly cloudy.
3	36 06 N	285 09	105	71	29	Moderate breeze to calm. Smooth sea. Partly cloudy, lightning.
4	36 40 N	284 12	57	195	11	Calm to moderate breeze. Smooth sea. Partly cloudy. Under engine power.
4	Newport News		43			At 11^h p. m. anchored off docks.
8	Newport News					Left ancorage at 11^h50^m a. m. Under engine power.
9	Chesapeake Bay					Swinging ship under engine power. Proceeding up Potomac River.
10	Washington					Docked at 8^h30^m p. m. Under engine power.

Total distance, 2,275 miles. Time of passage, 24.4 days. Average day's run, 93.0 miles.

TABLE 22.—*Summary of Passages for Cruise V of the Carnegie.*

Passage	Length of passage	Time of passage	Average day's run
	miles	days	miles
Buenos Aires to Talcahuano	3,863	37.9	102
Talcahuano to Callao	3,568	30.4	117
Callao to Balboa Anchorage	3,212	26.3	122
Balboa Anchorage to Balboa to Cristobal	58	0.5	....
Cristobal to Newport News	2,275	24.4	93
Newport News to Chesapeake Bay to Washington	219	2.4	....

Length of Cruise V, 13,195 miles. Time at sea, 121.9 days. Average day's run, 108 miles.

J. P. AULT: ABSTRACT OF LOG, CRUISE VI, 1919-1921.

WASHINGTON, D. C., TO DAKAR, FRENCH WEST AFRICA.

Date		Noon position Lat.	Noon position Long. E. of Gr.	Day's run	Current Dir.	Current Am't	Remarks
1919		° ′	° ′	*miles*	°	*miles*	
Oct	9	Washington, D. C.					Left dock at 12^h46^m p. m. Anchored overnight.
	15[1]	Old Point Comfort.					Anchored off Old Point Comfort at 1^h10^m p. m. Partly cloudy.
	19	Old Point Comfort.					Left Old Point Comfort at 7^h50^m a. m.
	19	36 53 N	284 08	23			Gentle breeze. E swell. Partly cloudy.
	20	35 36 N	286 14	128	141	18	Moderate to strong breeze. Rough sea, easterly swell. Partly cloudy, squally.
	21	36 50 N	287 11	87	45	35	Fresh breeze to whole gale. Rough sea, E swell. Squally, rain.
	22	38 24 N	291 37	231	48	40	Fresh breeze to strong gale. Heavy sea, SE swell. Partly cloudy, rain.
	23	38 31 N	295 47	196	106	15	Strong breeze to light air. Moderate sea. Cloudy, lightning.
	24	37 41 N	297 34	98	105	51	Light air to moderate breeze. Moderate sea, E swell. Overcast.
	25	36 49 N	297 58	55	118	19	Moderate breeze to moderate gale. Heavy sea. Cloudy.
	26	38 48 N	298 56	127	225	15	Strong breeze to moderate gale. Heavy sea, southerly swell. Cloudy.
	27	39 19 N	302 38	175	193	11	Strong to gentle breeze. Heavy sea, SW swell. Overcast, rain.
	28	38 53 N	306 26	179	108	29	Moderate breeze to calm. Long E swell. Partly cloudy, rain.
	29	38 26 N	309 17	136	99	34	Light breeze to fresh gale. Moderately heavy sea, W swell. Partly cloudy.
	30	38 52 N	314 14	236	143	31	Moderate gale increasing to storm. Heavy sea. Overcast, squally. Hove to at night.
	31	38 47 N	315 56	78	178	29	Storm. Very rough sea. Overcast, hail squalls. Hove to.
Nov	1	38 25 N	316 21	28	139	30	Storm to fresh breeze. Very rough and high sea. Overcast, squally, hail. Hove to.
	2	38 27 N	319 27	146	240	16	Fresh to gentle breeze. Rough sea, N swell. Cloudy.
	3	38 27 N	321 46	109	204	6	Gentle breeze. Moderate sea. Cloudy, drizzling.
	4	39 06 N	323 10	77	224	8	Light to strong breeze. Moderate sea, E swell. Partly cloudy, rain squalls.
	5	38 54 N	327 30	202	217	26	Fresh breeze to light air. Long N swell. Partly cloudy.
	6	38 48 N	329 28	92	124	10	Light breeze to calm. Long N swell. Partly cloudy. Sighted Flores Island. Under engine power.
	7	37 15 N	329 47	94	320	6	Light to strong breeze. Moderate choppy sea. Cloudy.
	8	35 35 N	329 41	100	348	6	Gentle breeze. Moderate sea. Partly cloudy, drizzling.
	9	35 37 N	331 56	110	65	6	Moderate breeze. Moderate sea. Cloudy, drizzling.
	10	35 12 N	334 08	110	188	3	Moderate breeze. Moderate sea. Partly cloudy.
	11	34 13 N	335 49	103	220	10	Light breeze. Moderate sea. Cloudy.
	12	33 03 N	338 01	129	13	13	Gentle to fresh breeze. Moderate sea. Overcast, rain squalls.
	13	30 18 N	340 13	199	45	20	Strong breeze. Moderate sea, W swell. Overcast.
	14	27 22 N	340 44	179	63	20	Moderate breeze. Moderate sea. Partly cloudy.
	15	25 37 N	340 35	105	76	13	Gentle breeze. Moderate sea. Overcast.
	16	25 13 N	340 23	27	268	13	Gentle breeze. Moderately smooth sea. Partly cloudy.
	17	24 45 N	340 29	28	296	16	Gentle breeze. Moderately smooth sea. Partly cloudy, drizzling, thunder, lightning.
	18	21 57 N	340 24	168	294	7	Moderate breeze. Moderate sea. Clear.
	19	19 10 N	341 06	172	8	10	Fresh breeze. Moderate sea. Harmattan, partly cloudy, foggy.
	20	16 30 N	341 54	166	191	5	Moderate breeze. Cross sea. Harmattan, partly cloudy.
	21	15 10 N	342 28	87	340	12	Gentle breeze. Moderate sea. Harmattan, partly cloudy.
	22	14 38 N	342 32	31	352	10	Gentle breeze. Smooth sea. Harmattan, partly cloudy. Hove to all night.
	22	Dakar		6			Dropped anchor in Dakar Harbor at 2^h30^m p. m. Under engine power.

Total distance, 4,217 miles. Time of passage, Old Point Comfort to Dakar, 34.3 days. Average day's run, 122.9 mile

[1] From October 10 to October 14 the *Carnegie* was at Solomons Island and in Chesapeake Bay, to swing ship and for atmospheric-electric observations. Under engine power.

DAKAR TO BUENOS AIRES, ARGENTINA.

Date		Lat.	Long.	Day's run	Dir.	Am't	Remarks
1919		° ′	° ′	*miles*	°	*miles*	
Nov	26	Dakar					Left anchorage at 2^h15^m p. m. Gentle breeze. Smooth sea. Clear. Under engine power.
	27	12 40 N	342 22	122	351	15	Gentle breeze. Smooth sea. Clear. Tide rips.
	28	10 28 N	343 07	138	289	16	Gentle breeze. Smooth sea. Partly cloudy. Tide rips.
	29	9 28 N	343 51	74	201	13	Light breeze. Smooth sea. Partly cloudy, lightning, thunder. Tide rips.

DAKAR TO BUENOS AIRES, ARGENTINA—*Concluded.*

Date		Noon position Lat.	Long. E. of Gr.	Day's run	Current Dir.	Am't	Remarks
1919		° ′	° ′	*miles*	°	*miles*	
Nov	30	8 40 N	344 42	69	95	9	Gentle breeze to light air. Smooth sea. Partly cloudy. Tide rips. Under engine power.
Dec	1	7 43 N	345 50	88	274	8	Light air to calm. Smooth sea. Clear. Tide rips. Under engine power.
	2	7 10 N	346 38	58	326	31	Gentle breeze to calm. Smooth sea. Partly cloudy. Under engine power.
	3	6 48 N	346 34	23	332	22	Calm to light breeze. Smooth sea. Partly cloudy. Under engine power.
	4	6 22 N	346 52	32	140	4	Light breeze. Smooth sea. Partly cloudy.
	5	5 56 N	348 05	78	113	4	Light breeze to calm. Smooth sea. Partly cloudy, squally, lightning, thunder. Under engine power.
	6	5 13 N	349 09	77	341	2	Light air. Smooth sea. Partly cloudy. Under engine power.
	7	4 50 N	350 29	84	11	5	Light air. Smooth sea. Cloudy. Under engine power.
	8	4 19 N	351 52	88	307	8	Light air. Moderate sea. Partly cloudy. Under engine power. Cape Palmas abeam at 4^h20^m p. m.
	9	3 40 N	352 19	48	334	11	Light breeze. Smooth sea. Partly cloudy. Under engine power.
	10	4 05 N	354 16	120	319	9	Light breeze. Smooth sea. Partly cloudy.
	11	4 06 N	355 20	64	63	16	Light air to calm. Smooth sea. Partly cloudy. Under engine power.
	12	4 02 N	356 17	57	90	19	Light breeze. Smooth sea. Partly cloudy.
	13	3 34 N	358 02	109	310	8	Light breeze. Smooth sea. Partly cloudy.
	14	2 55 N	359 22	89	283	11	Light breeze. Smooth sea. Partly cloudy.
	15	1 58 N	0 20	82	284	9	Light breeze. Smooth sea. Partly cloudy.
	16	0 59 N	1 42	100	289	19	Light to moderate breeze. Moderate sea. Partly cloudy, squally.
	17	0 00	3 48	140	282	31	Moderate breeze. Moderate sea. Partly cloudy.
	18	1 32 S	5 01	117	314	22	Fresh breeze. Moderate sea. Cloudy, rain, lightning.
	19	0 46 S	3 31	101	330	18	Light breeze to calm. Moderate sea. Overcast, light rain, lightning.
	20	0 18 S	3 06	37	17	15	Light breeze. Moderate sea. Partly cloudy.
	21	0 32 S	1 31	96	91	7	Gentle breeze. Moderate sea. Partly cloudy.
	22	1 18 S	0 05	95	241	20	Light air to moderate breeze. Moderately smooth sea. Partly cloudy.
	23	1 58 S	357 59	133	274	14	Light to moderate breeze. Moderate sea. Clear.
	24	3 20 S	355 49	153	176	3	Moderate breeze. Moderate sea. Partly cloudy.
	25	4 54 S	353 28	169	80	6	Fresh breeze. Choppy sea. Cloudy.
	26	6 54 S	351 09	183	92	7	Fresh breeze. Moderate sea. Overcast, drizzling.
	27	9 06 S	348 54	189	104	14	Fresh breeze. Moderate sea. Cloudy.
	28	11 05 S	346 40	178	34	13	Fresh breeze. Moderate sea. Cloudy.
	29	13 04 S	344 27	176	77	7	Fresh breeze. Moderate sea. Partly cloudy.
	30	15 16 S	342 14	185	13	10	Moderate breeze. Moderate sea. Partly cloudy, drizzling.
	31	17 27 S	340 06	180	3	17	Moderate breeze. Moderate sea. Clear.
1920							
Jan	1	19 11 S	338 25	135	11	12	Moderate breeze. Moderate sea. Partly cloudy.
	2	20 41 S	336 54	125	23	1	Gentle breeze. Moderate sea. Partly cloudy.
	3	22 12 S	335 22	125	14	15	Gentle breeze. Moderate sea. Clear.
	4	23 47 S	333 41	132	6	12	Gentle breeze. Moderate sea. Partly cloudy.
	5	24 51 S	332 51	78	113	10	Light breeze. Moderate sea. Clear.
	6	26 32 S	330 36	159	87	22	Moderate to fresh breeze. Moderate choppy sea. Cloudy, squally.
	7	28 04 S	329 25	112	23	10	Gentle breeze to calm. Choppy sea. Overcast, rain.
	8	28 51 S	326 35	155	93	8	Moderate to strong breeze. Long swell. Overcast, rain.
	9	30 07 S	323 04	199	92	24	Strong to light breeze. Long swell. Overcast, rain.
	10	31 01 S	321 40	90	100	8	Gentle breeze. Long swell. Partly cloudy, lightning.
	11	32 42 S	319 31	149	18	15	Moderate breeze. Moderate sea. Partly cloudy.
	12	32 57 S	317 57	80	18	5	Moderate breeze to calm. Moderate sea, long swell. Clear to overcast.
	13	33 48 S	316 05	106	23	5	Fresh breeze to light air. Moderate sea. Cloudy to clear.
	14	34 10 S	315 10	51	115	11	Calm to strong breeze. Moderate choppy sea. Partly cloudy.
	15	33 36 S	311 54	162	91	8	Strong wind to light breeze. Long swell. Cloudy.
	16	34 06 S	309 43	112	53	12	Gentle to fresh breeze. Moderate sea. Cloudy, "pampero" with heavy rain, hail, thunder, and lightning.
	17	34 36 S	306 02	185	141	20	Fresh breeze to calm. Moderate sea. Cloudy, squally. Sighted Cape Polonio light at 8^h05^m a. m.
	18	35 05 S	304 05	105	.....	.....	Fresh breeze. Smooth sea. Squally, changeable. Picked up pilot at Recalada at 2^h40^m p. m. Under engine power.
	19	Buenos Aires......		138	.....	.....	Anchored off Buenos Aires at 7^h15^m a. m. Docked at 5^h20^m p. m.

Total distance, 6,130 miles. Time of passage, 53.7 days. Average day's run, 114.1 miles.

BUENOS AIRES TO JAMESTOWN, ST. HELENA.

Date		Noon position Lat.	Long. E. of Gr.	Day's run	Current Dir.	Am't	Remarks
1920		° ′	° ′	miles	°	miles	
Feb	21	Buenos Aires					Left Buenos Aires under tow at 2^h05^m p. m.
	22	In River Plate					Under pilot's orders. Under engine power. Gentle breeze to moderate gale. Anchored overnight.
	23	35 10 S	303 41	114			Passed Recalada Lightship at noon. Gentle to strong breeze. Choppy sea. Partly cloudy. Under engine power.
	24	37 20 S	305 17	152	138	5	Fresh to light breeze. Moderate sea. Cloudy, lightning.
	25	39 29 S	307 40	170	139	28	Moderate breeze. Moderate sea. Cloudy, thunder and lightning.
	26	40 25 S	310 16	132	309	26	Fresh breeze. Moderate sea. Partly cloudy, lightning.
	27	41 34 S	311 53	100	294	10	Moderate breeze. Moderate sea, SW swell. Partly cloudy.
	28	44 00 S	313 38	166	31	21	Gentle breeze to fresh gale. Moderate sea, SW swell. Partly cloudy, lightning and thunder.
	29	46 02 S	317 51	216	5	23	Whole gale. Heavy sea. Overcast, squally, rain.
Mar	1	45 55 S	323 04	217	329	18	Whole gale to strong breeze. Heavy sea. Overcast, squally, rain.
	2	45 02 S	327 19	187	329	23	Strong to light breeze. Moderately rough sea. Overcast, squally.
	3	45 27 S	330 16	127	338	11	Moderate to light breeze. Moderate sea. Partly cloudy. Icebergs.
	4	45 45 S	334 57	198	248	8	Fresh breeze. Moderate sea. Partly cloudy. Iceberg.
	5	44 10 S	339 57	232	188	12	Fresh breeze. Moderate sea. Clear.
	6	42 17 S	344 33	230	196	14	Fresh breeze. Moderate sea. Partly cloudy.
	7	40 48 S	348 19	191	224	9	Moderate breeze. Moderate sea, westerly swell. Overcast.
	8	40 08 S	350 04	89	302	5	Gentle breeze to light air. Smooth sea, W swell. Overcast. Passed Gough Island.
	9	38 44 S	351 48	117	242	11	Gentle to fresh breeze. Smooth sea, E and W swell. Cloudy.
	10	36 56 S	353 04	123	189	10	Fresh breeze to light air. Choppy sea, E swell. Overcast, misty.
	11	36 10 S	354 02	66	45	12	Light air to calm. Smooth sea, E swell. Overcast, misty, hazy, and foggy.
	12	35 47 S	356 21	114	157	9	Gentle to fresh breeze. Smooth sea. Cloudy, drizzling.
	13	35 00 S	0 12	194	168	13	Fresh breeze. Moderate choppy sea. Cloudy, drizzling.
	14	32 56 S	2 06	156	203	12	Moderate breeze to light air. Moderate sea. Partly cloudy.
	15	32 10 S	2 36	52	337	7	Light air to calm. Smooth sea, SW swell. Partly cloudy. Under engine power.
	16	30 59 S	3 26	83	268	7	Light air to fresh breeze. Smooth sea, WSW swell. Partly cloudy.
	17	28 07 S	5 12	195	270	23	Fresh to strong breeze, SE trades. Moderately rough sea. Partly cloudy.
	18	25 10 S	7 17	209	233	16	Fresh SE trades. Rough sea. Partly cloudy.
	19	22 13 S	7 36	178	222	23	Moderate SE trades. Moderate sea. Overcast.
	20	19 39 S	7 52	155	242	18	Moderate SE trades. Smooth sea. Overcast.
	21	16 41 S	8 03	178	230	16	Moderate SE trades. Smooth sea. Overcast.
	22	13 59 S	7 28	165	218	11	Moderate SE trades. Smooth sea. Overcast.
	23	13 35 S	4 45	160	336	9	Moderate SE trades. Moderately smooth sea. Cloudy.
	24	14 02 S	2 06	157	4	3	Moderate to light SE trades. Smooth sea. Cloudy.
	25	14 41 S	359 29	158	351	5	Gentle to fresh SE trades. Smooth sea, SSW swell. Cloudy.
	26	15 46 S	356 15	198	333	10	Moderate SE trades. Moderate sea. Cloudy.
	27	St. Helena		112			Moderate breeze. Moderate sea. Cloudy. Anchored off Jamestown, St. Helena, at 9^h a. m.

Total distance, 5,291 miles. Time of passage, 34.8 days. Average day's run, 152.0 miles.

JAMESTOWN, ST. HELENA, TO CAPE TOWN.

Date		Lat.	Long. E. of Gr.	Day's run	Current Dir.	Am't	Remarks
1920		° ′	° ′	miles	°	miles	
Apr	3	St. Helena					Left St. Helena at 3^h20^m p. m. Moderate breeze. Moderately smooth sea. Partly cloudy.
	4	17 25 S	351 49	168	245	1	Moderate SE trades. Moderate sea. Overcast.
	5	19 35 S	349 24	190	245	6	Moderate SE trades. Moderate sea. Cloudy.
	6	21 37 S	347 33	161	329	3	Moderate to light SE trades. Moderate sea. Partly cloudy.
	7	22 43 S	346 38	75	202	6	Light breeze to calm. Smooth sea. Partly cloudy. Under engine power.
	8	24 16 S	345 42	107	99	4	Calm to moderate breeze. Smooth sea. Partly cloudy, squally.
	9	25 10 S	345 36	54	284	5	Strong breeze and calm. Smooth sea. Partly cloudy, squally, rain.
	10	26 46 S	344 22	117	33	8	Moderate breeze to moderate gale. Rough sea. Overcast, squally, rain.

JAMESTOWN, ST. HELENA, TO CAPE TOWN—*Concluded.*

Date	Noon position Lat.	Noon position Long. E. of Gr.	Day's run	Current Dir.	Current Am't	Remarks
1920	° ′	° ′	*miles*	°	*miles*	
Apr 11	29 10 S	342 37	170	290	9	Strong to light breeze. Cross sea, E swell. Overcast.
12	31 04 S	342 39	114	288	12	Light air to fresh breeze. Moderately smooth sea, E swell. Partly cloudy.
13	33 55 S	344 11	170	28	13	Fresh breeze to moderate gale. Rough sea. Overcast, lightning, thunder, rain.
14	35 59 S	346 29	183	57	21	Gentle breeze to fresh gale. Rough sea. Overcast, lightning, thunder, rain.
15	36 22 S	349 00	124	15	19	Moderate breeze to calm. Rough sea, SW swell. Partly cloudy. Sighted Tristan da Cunha Island.
16	37 04 S	353 13	207	357	11	Fresh breeze. Smooth sea, SW swell. Clear to overcast.
17	37 26 S	357 58	227	337	13	Fresh to strong breeze. Moderate sea. Cloudy, rain.
18	37 06 S	2 30	218	196	19	Strong breeze to moderate gale. Rough sea. Overcast, rain.
19	35 56 S	6 14	192	356	7	Strong to moderate breeze. Moderately rough sea, SW swell. Cloudy.
20	37 31 S	7 47	120	135	5	Fresh breeze. Moderate sea. Overcast, squally.
21	37 30 S	10 39	136	157	10	Moderate breeze. Moderate sea. Partly cloudy.
22	36 41 S	12 59	122	84	7	Gentle breeze. Smooth sea. Overcast, drizzling.
23	35 25 S	15 47	155	111	21	Gentle to fresh breeze. Smooth sea. Overcast, drizzling.
24	Cape Town.......		160	....		Moderate breeze. Smooth sea. Clear. Under engine power. Docked at Cape Town at 1^h10^m p. m.

Total distance, 3,170 miles. Time of passage, 20.9 days. Average day's run, 151.7 miles.

CAPE TOWN TO COLOMBO.

Date	Noon position Lat.	Noon position Long. E. of Gr.	Day's run	Current Dir.	Current Am't	Remarks
1920	° ′	° ′	*miles*	°	*miles*	
May 20	Cape Town..........		....	....		Left Cape Town at 3^h p. m. Light air. Smooth sea. Partly cloudy. Under engine power.
21	35 50 S	17 51	125	7	11	Moderate breeze. Moderate sea, W swell. Cloudy.
22	38 22 S	18 49	159	346	23	Moderate breeze to fresh gale. Rough sea. Overcast, squalls, rain, lightning.
23	39 40 S	22 05	172	44	28	Fresh gale to strong breeze. Rough sea. Overcast, squally, lightning, thunder.
24	39 40 S	25 18	149	36	40	Moderate breeze to moderate gale. Rough sea. Cloudy, squally, lightning.
25	39 21 S	29 01	173	198	17	Fresh gale. Rough sea. Cloudy, squally, lightning.
26	38 32 S	32 10	155	199	12	Fresh gale to strong breeze. Rough sea. Overcast, rain, lightning.
27	36 25 S	34 54	182	285	13	Strong breeze. Rough sea. Cloudy, squally.
28	34 43 S	37 45	172	328	19	Moderate breeze. Rough sea. Partly cloudy, squally.
29	33 47 S	40 42	157	276	11	Moderate breeze. Moderate sea. Cloudy, squally, rain.
30	33 09 S	44 09	177	180	7	Moderate to strong breeze. Moderate sea. Partly cloudy, lightning.
31	34 54 S	47 15	186	199	11	Strong breeze to calm. Rough sea. Overcast, squally, rain.
Jun 1	34 21 S	47 30	35	2	12	Calm to strong breeze. Moderate sea, E swell. Overcast, squally, rain, lightning, thunder.
2	32 33 S	48 32	119	312	14	Strong breeze to fresh gale. Rough sea. Cloudy, squally, rain, lightning.
3	31 23 S	52 08	196	311	13	Moderate gale. Rough sea. Cloudy, squally, rain.
4	30 38 S	56 22	223	333	28	Moderate to fresh gale. Rough to heavy sea. Cloudy, squally, rain.
5	30 08 S	60 49	232	350	33	Moderate gale. Heavy to rough sea. Cloudy, squally, rain.
6	28 00 S	63 22	185	302	23	Fresh breeze. Moderate sea. Partly cloudy.
7	26 06 S	65 27	159	99	14	Gentle breeze and calm. Smooth sea. Cloudy, squally.
8	23 52 S	66 05	139	96	2	Moderate breeze. Smooth sea. Partly cloudy.
9	20 53 S	65 55	179	32	13	Moderate breeze. Smooth sea. Partly cloudy.
10	17 49 S	65 29	186	289	8	Fresh breeze. Smooth sea. Cloudy, squally.
11	14 24 S	65 03	206	212	22	Strong SE trades. Rough sea. Partly cloudy, squally.
12	10 39 S	64 32	227	259	29	Strong SE trades. Cross sea. Partly cloudy, squally.
13	7 21 S	64 06	200	249	34	Moderate trades. Cross sea. Partly cloudy.
14	5 04 S	63 29	142	232	37	Moderate to gentle breeze. Moderate sea. Partly cloudy.
15	3 11 S	63 34	113	138	18	Gentle breeze and calm. Smooth sea. Partly cloudy, squally, rain.
16	2 02 S	63 11	72	197	15	Light to moderate breeze. Smooth sea. Partly cloudy.
17	0 03 S	62 56	121	134	16	Moderate breeze. Smooth sea. Partly cloudy.

CAPE TOWN TO COLOMBO—*Concluded.*

Date		Noon position Lat.	Noon position Long. E. of Gr.	Day's run	Current Dir.	Current Am't	Remarks
1920		° ′	° ′	*miles*	°	*miles*	
Jun	18	1 57 N	62 35	121	116	23	Gentle breeze. Smooth sea. Partly cloudy.
	19	3 49 N	61 44	124	87	9	Gentle breeze. Smooth sea. Partly cloudy.
	20	6 19 N	60 43	162	59	11	Moderate breeze. Moderate sea. Partly cloudy.
	21	9 20 N	59 26	196	147	11	Strong breeze. Choppy sea. Partly cloudy, squally, rain.
	22	12 50 N	59 16	225	105	24	Moderate gale. Rough sea. Cloudy, squally.
	23	12 25 N	62 50	228	38	11	Moderate gale. Rough sea. Cloudy, squally.
	24	11 04 N	66 02	205	26	13	Moderate gale to moderate breeze. Rough sea. Partly cloudy, squally.
	25	9 40 N	68 57	191	77	10	Moderate breeze. Moderate sea. Overcast, squally, thunder, lightning, rain.
	26	8 39 N	71 37	170	304	5	Moderate breeze. Moderate sea. Overcast, squally, rain. Passed Minikoi Island.
	27	8 07 N	73 50	136	39	4	Gentle breeze, calm. Smooth sea. Overcast, rain, thunder, lightning.
	28	7 39 N	75 35	107	197	9	Gentle to moderate breeze. Smooth sea. Cloudy, squally, rain.
	29	7 25 N	78 46	190	71	9	Moderate breeze. Moderate sea. Cloudy, squally, rain. Hove to overnight.
	30	Colombo.........		69	....		Fresh breeze. Moderate sea. Overcast, squally, rain. Anchored in Colombo Harbor at 10ʰ a. m.

Total distance, 6,665 miles. Time of passage, 40.8 days. Average day's run, 163.4 miles.

COLOMBO TO FREMANTLE.

Date		Noon position Lat.	Noon position Long. E. of Gr.	Day's run	Current Dir.	Current Am't	Remarks
1920		° ′	° ′	*miles*	°	*miles*	
Jul	24	Colombo.........		....	....		Left Colombo Harbor at 9ʰ a. m.
	24	6 52 N	79 40	12	....		Light breeze. Choppy sea, NW swell. Partly cloudy. Under engine power.
	25	4 37 N	80 08	137	66	17	Fresh breeze. Rough sea. Overcast, squally, rain.
	26	4 24 N	83 16	188	35	18	Strong to moderate breeze. Moderate sea. Cloudy.
	27	3 17 N	86 35	210	85	9	Fresh breeze. Moderate sea. Partly cloudy, squally, rain.
	28	2 11 N	89 52	207	52	7	Fresh to moderate breeze. Moderate sea. Overcast, rain.
	29	1 28 N	92 12	147	318	11	Moderate breeze to calm. Smooth sea. Overcast, rain, lightning. Under engine power.
	30	1 06 N	93 22	73	323	10	Calm and light airs. Smooth sea. Overcast. Under engine power.
	31	0 10 S	94 02	85	310	11	Calm and light airs. Smooth sea. Cloudy. Under engine power.
Aug	1	1 44 S	94 06	95	240	17	Calm and light airs. Smooth sea. Overcast, rain. Under engine power.
	2	3 30 S	94 22	107	209	10	Calm and light airs. Smooth sea. Cloudy. Under engine power.
	3	4 57 S	95 13	101	105	13	Calm and light airs. Smooth sea. Partly cloudy, lightning. Under engine power.
	4	6 29 S	95 36	95	166	2	Calm and light airs. Smooth sea. Overcast, rain. Under engine power.
	5	8 05 S	95 35	96	230	6	Calm and light airs. Smooth sea, S swell. Partly cloudy. Under engine power.
	6	9 20 S	94 56	84	198	24	Calm. Smooth sea, southerly swell. Clear. Under engine power.
	7	10 22 S	94 20	72	207	27	Calm to gentle breeze. Smooth sea, SW swell. Clear. Under engine power.
	8	12 10 S	93 03	132	238	18	Moderate breeze. Moderate sea, SW swell. Overcast, squally, rain.
	9	14 42 S	90 37	207	60	3	Strong breeze. Rough sea. Partly cloudy, squally, rain.
	10	17 26 S	88 01	223	113	6	Strong breeze. Moderately rough sea. Cloudy, squally.
	11	20 05 S	85 37	209	272	2	Fresh breeze. Moderate sea. Partly cloudy, rain, squally.
	12	22 24 S	83 36	179	54	3	Fresh to strong breeze. Moderate sea. Partly cloudy, squally, rain.
	13	24 26 S	81 41	161	49	14	Fresh breeze. Moderate sea. Cloudy, squally.
	14	26 09 S	79 23	163	71	6	Gentle to moderate breeze. Smooth sea. Cloudy, squally.
	15	25 49 S	80 03	41	321	8	Moderate to strong breeze. Choppy sea. Cloudy, squally, rain.
	16	27 07 S	78 08	130	90	5	Moderate breeze. Choppy sea. Cloudy, squally.
	17	28 08 S	76 41	98	90	2	Light breeze. Moderate sea, SW swell. Partly cloudy, squally, rain.
	18	29 16 S	75 01	111	348	6	Gentle breeze. Smooth sea. Overcast.
	19	30 29 S	74 06	87	220	4	Gentle breeze. Smooth sea. Partly cloudy.
	20	32 27 S	75 48	147	336	10	Moderate breeze. Smooth sea. Cloudy, heavy dew.
	21	33 45 S	79 22	196	343	8	Fresh breeze. Moderate sea. Partly cloudy.

COLOMBO TO FREMANTLE—*Concluded.*

Date	Noon position Lat.	Noon position Long. E. of Gr.	Day's run	Current Dir.	Current Am't	Remarks
1920	° ′	° ′	*miles*	°	*miles*	
Aug 22	34 40 S	83 23	207	239	9	Fresh breeze. Moderate sea. Cloudy, heavy dew.
23	35 06 S	87 09	187	204	6	Fresh breeze. Moderate sea. Cloudy, foggy, rain.
24	35 18 S	91 38	220	226	10	Strong breeze to moderate gale. Rough sea. Overcast, squally, rain.
25	35 40 S	95 24	186	323	9	Moderate gale to fresh breeze. Rough sea. Cloudy.
26	35 30 S	99 20	192	172	7	Strong breeze. Moderate sea. Cloudy, rain.
27	35 04 S	102 56	178	211	15	Fresh breeze. Moderate sea. Partly cloudy, squally.
28	34 38 S	106 55	198	256	15	Strong breeze to fresh gale. Rough sea. Partly cloudy, squally, rain.
29	33 51 S	110 07	166	135	8	Fresh gale to strong breeze. Rough sea. Overcast, squally, rain, lightning.
30	32 21 S	113 11	179	275	14	Moderate gale to light air. Rough sea. Partly cloudy.
31	32 21 S	115 10	100	193	7	Gentle breeze to light air. Moderate to smooth sea. Partly cloudy.
31	Gage Roads.......		44	.....	.....	Anchored off Fremantle at 9^h55^m p. m. Under engine power.
Sep 1	Fremantle		.....	.....	.....	Docked at Fremantle at 9^h45^m a. m.

Total distance, 5,650 miles. Time of passage, 38.5 days. Average day's run, 146.8 miles.

FREMANTLE TO PORT LYTTELTON.

Date	Lat.	Long. E. of Gr.	Day's run	Dir.	Am't	Remarks
1920	° ′	° ′	*miles*	°	*miles*	
Oct 1	Fremantle		.....	.....	.....	Left Fremantle at 10^h20^m a. m. under tow. Gentle breeze. Smooth sea. Partly cloudy.
2	33 53 S	114 45	141	69	13	Strong breeze to moderate gale. Rough sea. Partly cloudy, squally. Under engine power to clear Cape Leeuwin.
3	35 23 S	116 09	113	112	23	Strong breeze to calm. Long rolling sea, W swell. Partly cloudy.
4	37 25 S	117 24	137	112	12	Fresh breeze. Rough sea, W swell. Cloudy, heavy dew.
5	40 40 S	119 42	222	27	6	Strong breeze to fresh gale. Rough sea. Overcast, hazy.
6	43 14 S	121 46	180	231	3	Moderate gale. Rough sea. Cloudy, foggy, lightning.
7	44 25 S	125 58	195	0	18	Moderate gale to calm. Rough sea. Overcast, squally.
8	44 44 S	127 29	67	328	9	Calm to moderate breeze. Smooth sea, W swell. Overcast, drizzling.
9	46 38 S	130 18	164	277	9	Moderate to fresh breeze. Moderate sea. Overcast, misty.
10	48 45 S	134 46	221	162	7	Fresh breeze to moderate gale. Moderate sea. Overcast, misty, rain. Sighted considerable kelp. Aurora australis all night.
11	49 58 S	138 41	170	149	8	Moderate gale to strong breeze. Moderate sea. Cloudy. Aurora australis all night.
12	50 22 S	143 35	190	171	15	Strong breeze to strong gale. Rough sea. Cloudy, squally, rain, hail.
13	50 33 S	148 03	171	206	32	Strong to moderate gale. Heavy sea. Cloudy, squally, rain.
14	49 48 S	152 08	164	160	21	Moderate gale. Rough sea. Cloudy, squally, rain, snow.
15	48 07 S	155 45	175	157	17	Moderate to strong gale. Rough sea. Overcast, squally, rain, hail.
16	47 30 S	160 04	177	325	20	Fresh gale to strong breeze. Rough sea. Overcast, squally, hail.
17	48 00 S	164 46	192	313	12	Fresh breeze. Moderate sea. Cloudy, squally, rain. Sighted Snares Islands.
18	47 03 S	169 28	197	205	5	Moderate gale to calm. Moderate sea. Partly cloudy, squally, rain. Sighted Stewart Island.
19	45 24 S	171 28	130	36	15	Light airs. Smooth sea. Partly cloudy. Under engine power.
20	44 29 S	172 48	79	112	11	Light airs. Smooth sea. Partly cloudy. Under engine power.
21	Port Lyttelton....		72	.....	.....	Gentle breeze. Smooth sea. Cloudy. Anchored off Port Lyttelton at 3^h15^m a. m. Docked at 12^h30^m p. m.

Total distance, 3,157 miles. Time of passage, 19.7 days. Average day's run, 160.3 miles.

PORT LYTTELTON TO PAPEETE.

Date	Lat.	Long. E. of Gr.	Day's run	Dir.	Am't	Remarks
1920	° ′	° ′	*miles*	°	*miles*	
Nov 19	Port Lyttelton.....		.....	.....	.....	Left dock under tow at 1^h15^m p. m. Light air to strong breeze. Smooth sea. Partly cloudy, heavy dew.
20	44 43 S	175 32	140	238	9	Fresh breeze to light air. Moderate sea, S swell. Cloudy.
21	44 56 S	176 54	60	336	4	Calm to light breeze. Smooth sea. Hazy, foggy.
22	46 08 S	178 14	92	205	6	Light breeze to fresh gale. Rough sea. Overcast, misty, rainy. Crossed 180th meridian.
22	46 13 S	182 37	182	179	6	Moderate gale to moderate breeze. Rough sea. Overcast, foggy.

PORT LYTTELTON TO PAPEETE—*Concluded.*

Date	Noon position Lat.	Long. E. of Gr.	Day's run	Current Dir.	Am't	Remarks
1920	° ′	° ′	*miles*	°	*miles*	
Nov 23	46 26 S	187 02	183	216	17	Strong to moderate breeze. Rough sea. Overcast.
24	46 29 S	190 12	181	265	10	Gentle to fresh breeze. Smooth sea. Overcast, misty.
25	46 44 S	195 07	203	208	19	Fresh breeze. Smooth sea. Overcast, foggy, hazy.
26	46 43 S	199 46	192	260	12	Fresh to moderate breeze. Moderate sea. Overcast, misty.
27	46 54 S	204 26	192	176	13	Moderate breeze to moderate gale. Moderate sea. Overcast, rain, foggy.
28	45 30 S	207 47	162	227	7	Moderate gale to light breeze. Smooth sea. Overcast.
29	44 12 S	209 48	116	287	13	Light to fresh breeze. Moderate sea. Partly cloudy.
30	43 22 S	211 40	95	314	11	Calm to strong breeze. Smooth sea, SE swell. Partly cloudy.
Dec 1	43 28 S	216 02	191	165	9	Moderate gale to moderate breeze. Moderately rough sea. Overcast, misty.
2	41 40 S	217 41	131	172	13	Moderate to gentle breeze. Smooth sea. Cloudy, heavy dew.
3	39 30 S	219 28	152	185	4	Gentle to fresh breeze. Smooth sea. Cloudy.
4	37 23 S	222 28	190	214	9	Fresh to moderate breeze. Smooth sea. Cloudy, heavy dew.
5	36 11 S	225 45	174	178	9	Moderate to strong breeze. Rough sea. Cloudy.
6	34 50 S	226 51	89	67	12	Moderate gale to gentle breeze. Moderate sea. Partly cloudy.
7	33 14 S	227 33	102	345	9	Gentle breeze to calm. Long sea from SW. Partly cloudy. Under engine power.
8	32 12 S	227 35	62	56	7	Light airs. Smooth sea, SW swell. Partly cloudy.
9	30 57 S	228 15	82	47	28	Light breeze. Smooth sea. Partly cloudy, lightning.
10	30 20 S	228 15	38	53	15	Fresh to light breeze. Moderately smooth sea. Partly cloudy.
11	30 08 S	227 30	41	117	15	Fresh breeze to calm. Choppy sea, SW swell. Cloudy, squally.
12	29 30 S	226 16	74	281	13	Moderate breeze. Smooth sea, SW swell. Partly cloudy.
13	28 07 S	224 12	137	177	11	Moderate breeze and calm. Smooth sea, SW swell. Partly cloudy. Under engine power.
14	27 25 S	222 58	78	175	9	Gentle breeze. Smooth sea. Partly cloudy.
15	26 18 S	221 31	101	161	16	Moderate breeze. Moderate sea. Partly cloudy.
16	24 09 S	219 18	176	163	23	Moderate breeze. Moderate sea. Partly cloudy.
17	22 17 S	217 00	169	175	18	Moderate breeze. Moderate sea. Partly cloudy, squally, rain.
18	20 50 S	215 04	138	181	18	Gentle breeze. Smooth sea. Partly cloudy, lightning.
19	19 31 S	213 34	116	169	4	Gentle breeze to calm. Smooth sea. Partly cloudy, thunder, lightning, rain.
20	18 43 S	212 01	101	219	6	Gentle breeze. Smooth sea. Partly cloudy, thunder, lightning, rain.
21	18 16 S	212 30	39	155	11	Gentle breeze. Smooth sea. Partly cloudy, lightning, thunder. Under engine power.
22	17 48 S	211 20	72	50	7	Light air and calm. Smooth sea. Partly cloudy. Under engine power.
23	Papeete.		61	. . . .		Calm. Smooth sea. Partly cloudy. Under engine power. Anchored in Papeete harbor at 8^h30^m a. m.

Total distance, 4,262 miles. Time of passage, 34.8 days. Average day's run, 122.5 miles.

PAPEETE TO SAN FRANCISCO.

Date	Lat.	Long. E. of Gr.	Day's run	Dir.	Am't	Remarks
1921	° ′	° ′	*miles*	°	*miles*	
Jan 3	Papeete.	. . . . . .	. . . . . .	. . . . . .	. . . . . .	Left anchorage at 2^h p. m. Gentle breeze. Smooth sea. Squally, rain.
4	16 30 S	209 26	82	201	11	Gentle breeze. Smooth sea. Partly cloudy.
5	14 29 S	208 56	125	235	15	Moderate breeze. Moderate sea. Partly cloudy, squally.
6	12 09 S	208 47	140	235	20	Moderate to gentle breeze. Moderate sea. Cloudy, squally, lightning, rain.
7	10 28 S	208 16	105	184	12	Gentle to moderate breeze. Moderate sea. Partly cloudy, squally.
8	8 09 S	207 34	146	218	14	Moderate breeze. Moderate sea. Partly cloudy.
9	5 28 S	207 06	163	236	17	Moderate breeze. Moderate sea. Partly cloudy, squally, heavy dew.
10	3 36 S	206 04	127	236	25	Gentle breeze. Smooth sea. Partly cloudy.
11	0 57 S	204 42	179	224	33	Moderate to fresh breeze. Smooth sea, NE swell. Partly cloudy.
12	2 12 N	204 09	191	249	14	Fresh breeze. Moderate sea. Partly cloudy.
13	3 35 N	201 39	172	146	18	Moderate to fresh breeze. Moderate sea. Partly cloudy. Hove to overnight.

PAPEETE TO SAN FRANCISCO—*Concluded.*

Date		Noon position Lat.	Long. E. of Gr.	Day's run	Current Dir.	Am't	Remarks
1921		° ′	° ′	*miles*	°	*miles*	
Jan	14	3 55 N	200 43	60	105	21	Moderate breeze. Moderate sea. Partly cloudy.
	14	Fanning Island....		8	......	.....	Hove to at Whaler Anchorage from 1h25m p. m. to 3h40m p.m.
	15	5 52 N	200 25	119	213	13	Moderate breeze. Smooth sea. Partly cloudy.
	16	8 24 N	200 06	153	159	8	Moderate breeze. Moderate sea. Partly cloudy, squally, rain.
	17	10 55 N	199 35	154	175	7	Moderate breeze. Moderate sea. Partly cloudy, squally, rain, lightning.
	18	13 56 N	198 35	190	264	19	Moderate to strong breeze. Moderately rough sea. Overcast, squally, rain.
	19	16 16 N	197 28	155	257	27	Fresh breeze to calm. Moderate sea. Overcast, rain.
	20	17 38 N	196 10	111	224	17	Light to moderate breeze. Smooth sea. Cloudy, drizzling.
	21	19 04 N	195 21	97	194	16	Gentle to fresh breeze. Moderate sea. Cloudy, squally, rain.
	22	21 05 N	194 08	140	114	25	Fresh to light breeze. Smooth sea, N swell. Overcast, rain.
	23	22 24 N	192 07	137	145	5	Fresh to light breeze. Moderate sea, N swell. Cloudy, rain.
	24	23 19 N	190 32	108	295	11	Light air to moderate breeze. Moderate sea. Overcast, squally, rain.
	25	25 25 N	188 39	163	179	7	Moderate breeze. Moderate sea. Overcast, rain. Passed Laysan Island.
	26	27 12 N	187 24	126	265	12	Gentle breeze. Smooth sea, NE swell. Partly cloudy.
	27	29 05 N	186 36	121	102	21	Moderate breeze. Smooth sea. Partly cloudy, heavy dew.
	28	31 16 N	186 22	131	179	16	Strong breeze. Moderate sea. Cloudy, squally, rain.
	29	32 36 N	188 50	148	237	14	Moderate breeze to light air. Moderate sea, long westerly swell. Partly cloudy.
	30	34 25 N	189 15	111	115	9	Moderate breeze to moderate gale. Rough sea. Cloudy, squally.
	31	36 23 N	191 35	165	216	13	Moderate gale to moderate breeze. Rough sea. Cloudy, squally.
Feb	1	38 20 N	194 20	176	215	4	Moderate gale to calm. Rough to long rolling sea. Overcast, rain.
	2	38 40 N	195 48	71	27	12	Calm to gentle breeze. Moderate to long rolling sea. Cloudy, heavy dew.
	3	39 01 N	198 04	109	310	10	Light breeze to moderate gale. Smooth to rough sea, SW swell. Cloudy, misty.
	4	40 02 N	201 44	181	319	11	Moderate gale to moderate breeze. Rough sea. Overcast, misty, foggy.
	5	39 56 N	204 51	143	307	26	Moderate breeze to moderate gale. Moderately rough sea. Overcast, misty, foggy, rain.
	6	40 06 N	208 56	187	29	17	Fresh gale to light breeze. Rough sea. Overcast, squally, rain.
	7	39 54 N	211 33	121	351	7	Moderate breeze to moderate gale. Smooth to rough sea, W swell. Overcast, foggy, rain.
	8	39 26 N	214 57	160	21	12	Moderate gale to strong breeze. Rough sea. Overcast, foggy, rain.
	9	39 02 N	218 24	163	299	19	Moderate gale to fresh breeze. Rough sea. Overcast, misty, foggy, rain.
	10	38 42 N	221 35	150	277	8	Fresh breeze to moderate gale. Rough sea. Overcast, misty, foggy, rain.
	11	38 26 N	223 51	108	276	8	Moderate gale to light air to strong gale. Heavy sea. Overcast, squally, rain. Vessel hove to.
	12	38 00 N	225 19	73	278	8	Fresh to strong gale. Heavy sea. Overcast, squally, rain, hail. Vessel hove to.
	13	37 43 N	226 19	51	140	18	Fresh to moderate gale. Heavy sea. Partly cloudy, squally, rain, hail. Vessel hove to.
	14	37 29 N	227 06	39	180	12	Strong to light breeze. Heavy to long rolling sea. Cloudy, squally, rain.
	15	38 01 N	230 12	151	270	12	Fresh breeze to fresh gale. Rough sea. Overcast, squally, rain. Vessel hove to. Sudden sharp squall of hurricane force at 7h20m p. m. carried away two sails.
	16	38 50 N	230 49	56	261	16	Moderate gale to fresh breeze. Rough sea. Cloudy, squally, rain. Vessel hove to.
	17	38 36 N	231 00	17	182	4	Calm to light breeze. Long rolling sea. Partly cloudy. Under engine power.
	18	38 19 N	233 34	122	332	10	Light to fresh breeze. Smooth sea. Partly cloudy.
	19	37 54 N	236 30	141	314	19	Gentle breeze to calm. Smooth sea. Cloudy, misty. Under engine power.
	19	San Francisco.....		58	....		Anchored at 10h40m p. m. in San Francisco Bay.

Total distance, 6,099 miles. Time of passage, 47.3 days. Average day's run, 128.9 miles.

SAN FRANCISCO TO HONOLULU.

Date	Noon position Lat.	Noon position Long. E. of Gr.	Day's run	Current Dir.	Current Am't	Remarks
1921	° ′	° ′	*miles*	°	*miles*	
Mar 28	San Francisco					Left dock under tow at 4 p. m. Moderate breeze. Moderate sea. Overcast, foggy.
29	36 08 N	235 26	149	136	14	Moderate to fresh breeze. Moderate sea. Cloudy.
30	33 34 N	232 54	198	122	28	Fresh to gentle breeze. Moderate sea. Cloudy.
31	31 56 N	230 46	145	104	13	Gentle to moderate breeze. Moderate sea. Cloudy.
Apr 1	30 30 N	228 56	128	89	14	Moderate to gentle breeze. Smooth sea. Overcast.
2	29 04 N	227 10	126	114	11	Gentle to moderate breeze. Smooth sea. Overcast.
3	27 04 N	224 47	174	98	14	Moderate to strong breeze. Moderate sea. Overcast, squally, rain.
4	26 10 N	221 13	199	125	18	Strong to fresh breeze. Rough sea. Cloudy, squally.
5	25 34 N	218 19	161	63	11	Moderate breeze. Moderate sea. Partly cloudy, squally.
6	25 14 N	216 03	125	41	14	Moderate to light breeze. Moderate sea. Cloudy.
7	25 06 N	214 43	72	358	15	Calm to fresh breeze. Moderate to long rolling sea. Partly cloudy, rain.
8	23 41 N	211 55	175	146	16	Fresh to moderate breeze. Moderate sea. Cloudy.
9	23 02 N	209 30	139	104	13	Moderate breeze. Long rolling sea. Cloudy.
10	22 15 N	207 07	140	143	12	Moderate breeze. Moderate sea. Partly cloudy.
11	21 46 N	204 18	159	93	17	Fresh to strong breeze. Moderate sea. Partly cloudy, squally, rain.
12	Honolulu		132			Strong breeze. Moderate sea. Partly cloudy. Docked at 8^h40^m a. m.

Total distance, 2,222 miles. Time of passage, 14.7 days. Average day's run, 151.2 miles.

HONOLULU TO PAGO PAGO.

Date	Noon position Lat.	Noon position Long. E. of Gr.	Day's run	Current Dir.	Current Am't	Remarks
1921	° ′	° ′	*miles*	°	*miles*	
Apr 28	Honolulu					Left dock under tow at 11^h10^m a. m.
28	21 14 N	202 04	9			Moderate breeze to calm. Smooth sea. Partly cloudy. Under engine power.
29	23 02 N	200 24	143	180	8	Fresh to moderate breeze. Moderate sea. Partly cloudy.
30	25 04 N	198 44	153	177	13	Moderate breeze. Moderate sea. Partly cloudy.
May 1	27 18 N	198 04	138	188	10	Moderate breeze. Moderate sea. Overcast.
2	29 32 N	197 25	139	227	16	Moderate breeze. Moderate sea. Overcast.
3	32 14 N	197 18	161	265	11	Moderate to fresh breeze. Moderate sea. Overcast, rain.
4	33 51 N	199 38	153	267	16	Moderate gale to calm. Rough sea. Cloudy, squally, drizzling, lightning.
5	34 00 N	200 27	42	331	4	Calm to gentle breeze. Smooth sea, SE swell. Partly cloudy. Under engine power.
6	34 07 N	202 25	98	233	11	Gentle breeze. Smooth sea, SE swell. Partly cloudy, squally.
7	34 10 N	204 12	88	220	9	Light breeze. Smooth sea, SE swell. Partly cloudy.
8	34 11 N	205 40	73	212	5	Light breeze. Smooth sea. Partly cloudy. Under engine power.
9	33 41 N	207 16	86	241	15	Light to moderate breeze. Smooth sea, SE swell. Partly cloudy.
10	33 36 N	209 50	128	293	12	Moderate to fresh breeze. Moderate to rough sea. Cloudy, squally, rain.
11	34 08 N	213 05	165	213	20	Fresh breeze. Rough sea. Cloudy, squally, rain.
12	34 16 N	215 55	141	294	12	Fresh to light breeze. Moderate sea. Cloudy, rain.
13	33 44 N	217 09	69	347	3	Light breeze to calm. Smooth sea. Cloudy. Under engine power.
14	32 53 N	218 47	97	290	11	Calm to moderate breeze. Smooth sea. Cloudy. Under engine power.
15	30 39 N	220 12	153	314	21	Moderate breeze. Smooth sea. Partly cloudy.
16	28 31 N	221 36	147	319	16	Moderate breeze. Moderate sea. Cloudy.
17	26 19 N	222 30	141	306	11	Moderate breeze. Moderate sea. Cloudy, squally, rain.
18	24 19 N	223 39	135	308	19	Moderate to fresh breeze. Moderate sea. Cloudy, drizzling, squally.
19	21 59 N	224 38	150	304	20	Fresh to moderate breeze. Moderate sea. Cloudy, squally, rain.
20	20 09 N	225 44	126	314	17	Moderate breeze. Moderate sea. Cloudy, squally, rain.
21	18 07 N	226 34	130	310	14	Moderate breeze. Moderate sea. Cloudy.
22	16 24 N	225 50	111	322	18	Gentle to moderate breeze. Moderately smooth sea. Cloudy.
23	14 28 N	224 34	138	335	13	Moderate breeze. Moderate sea. Partly cloudy.
24	12 23 N	222 57	156	325	10	Moderate to fresh breeze. Moderate sea. Overcast, rain.
25	10 30 N	220 57	163	20	7	Fresh to moderate breeze. Moderate sea. Overcast, rain, lightning.
26	9 05 N	219 19	129	5	12	Fresh breeze to light air. Moderate sea. Cloudy, squally, lightning.

HONOLULU TO PAGO PAGO—*Concluded.*

Date		Noon position Lat.	Long. E. of Gr.	Day's run	Current Dir.	Am't	Remarks
1921		° ′	° ′	*miles*	°	*miles*	
May	27	7 55 N	217 59	105	43	9	Gentle breeze to calm. Smooth sea, NE swell. Cloudy, squally, lightning. Under engine power.
	28	6 54 N	217 31	67	61	19	Light breeze and calm. Smooth sea, NE swell. Cloudy, squally, lightning.
	29	5 49 N	217 09	68	69	33	Light breeze and calm. Smooth sea. Cloudy, lightning, thunder, drizzling. Under engine power.
	30	5 09 N	216 20	63	48	30	Light variable breeze. Smooth sea. Overcast, lightning, thunder, rain. Under engine power.
	31	4 35 N	215 26	64	31	24	Light breeze. Smooth sea. Partly cloudy. Swinging ship under engine power.
Jun	1	3 59 N	214 42	56	31	16	Light air to moderate breeze. Smooth sea. Cloudy, squally, rain.
	2	2 40 N	213 08	127	3	16	Moderate to fresh breeze. Smooth sea. Partly cloudy.
	3	0 27 N	211 30	162	58	16	Fresh to moderate breeze. Moderate sea. Partly cloudy.
	4	0 44 S	210 28	95	56	19	Gentle breeze. Smooth sea. Partly cloudy.
	5	1 45 S	209 35	81	60	16	Gentle breeze. Smooth sea. Partly cloudy.
	6	2 59 S	208 10	112	18	16	Moderate to light breeze. Smooth sea. Partly cloudy.
	7	3 42 S	207 10	74	302	20	Light air to moderate breeze. Smooth sea. Partly cloudy.
	8	5 11 S	205 49	121	309	18	Moderate breeze. Moderately smooth sea. Partly cloudy.
	9	6 40 S	204 32	118	335	16	Gentle breeze. Smooth sea. Partly cloudy.
	10	7 47 S	203 37	86	339	4	Gentle breeze. Long rolling sea. Cloudy, squally, rain.
	11	8 44 S	202 45	76	146	6	Gentle breeze to calm. Long rolling sea. Partly cloudy, squally, rain. Under engine power.
	12	8 56 S	201 56	50	346	6	Calm. Smooth sea. Partly cloudy. Under engine power. Hove to off Penrhyn Island from 9ʰ a. m. to 7ʰ05ᵐ p. m.
	13	9 29 S	201 03	62	337	6	Light breeze. Long rolling sea. Partly cloudy, squally, rain, lightning. Under engine power.
	14	10 12 S	200 04	72	187	11	Light to moderate breeze. Long rolling sea. Partly cloudy, lightning.
	15	10 24 S	198 56	67	331	11	Moderate breeze. Long rolling sea. Cloudy, squally, lightning, thunder, rain. Hove to off Manihiki Island from noon to 4ʰ p. m.
	16	11 06 S	197 20	104	243	5	Moderate breeze. Long rolling sea. Partly cloudy, lightning, squally, rain.
	17	11 39 S	195 52	92	334	5	Calm to fresh breeze. Long rolling sea. Cloudy, squally, rain, lightning.
	18	12 14 S	194 24	92	354	12	Light to fresh breeze. Long rolling sea. Partly cloudy.
	19	13 21 S	192 17	141	346	10	Moderate breeze. Long rolling sea. Partly cloudy.
	20	14 07 S	190 02	139	315	14	Moderate breeze. Long rolling sea. Partly cloudy.
	20[1]	Pago Pago	....	48	.....	.....	Moored in Pago Pago Harbor, Samoa, at 6ʰ20ᵐ p. m. Under engine power.

Total distance, 5,904 miles. Time of passage, 53.3 days. Average day's run, 110.8 miles.

[1] The *Carnegie* left Pago Pago at 4ʰ p. m., June 28, under her own power and anchored in Apia Harbor at 9ʰ10ᵐ a. m., June 29.

APIA TO BALBOA, CANAL ZONE.

Date		Lat.	Long.	Day's run	Dir.	Am't	Remarks
1921		° ′	° ′	*miles*	°	*miles*	
Jul	25	Apia.....	....	.....	.....	.....	Left Apia Harbor at 4ʰ p. m. Under engine power. Moderate breeze. Moderate sea. Partly cloudy.
	26	13 18 S	187 32	53	329	8	Light air. Smooth sea. Partly cloudy. Under engine power.
	27	14 25 S	187 03	73	77	13	Light air. Smooth sea. Partly cloudy. Under engine power.
	28	15 11 S	187 56	69	18	13	Light to moderate breeze. Smooth sea, long swell. Partly cloudy.
	29	16 49 S	188 01	98	235	6	Moderate breeze to light air. Smooth sea, long swell. Partly cloudy, heavy dew.
	30	17 29 S	188 31	50	104	3	Calm to light air. Smooth sea. Partly cloudy. Under engine power.
	31	18 18 S	188 32	49	273	15	Light breeze. Smooth, long rolling sea. Partly cloudy, heavy dew.
Aug	1	19 21 S	187 51	71	284	12	Light to moderate breeze. Smooth sea, long swell. Partly cloudy.
	2	20 54 S	187 31	96	172	12	Light air. Smooth sea, SW swell. Partly cloudy.
	3	21 49 S	187 31	55	156	3	Light air to calm. Smooth sea, SW swell. Partly cloudy, heavy dew.
	4	23 17 S	187 38	88	50	11	Light air. Smooth sea, SW swell. Partly cloudy, foggy, lightning.
	5	24 20 S	188 04	67	160	17	Light breeze to calm. Smooth sea, SW swell. Partly cloudy. Under engine power.

APIA TO BALBOA, CANAL ZONE—*Continued.*

Date		Noon position Lat.	Noon position Long. E. of Gr.	Day's run	Current Dir.	Current Am't	Remarks
1921		° ′	° ′	*miles*	°	*miles*	
Aug	6	25 21 S	188 14	62	135	3	Gentle variable breeze. Smooth sea, SW swell. Overcast, squally.
	7	27 26 S	188 31	126	141	17	Fresh to strong breeze. Moderate sea. Cloudy, squally, rain.
	8	29 06 S	191 06	170	9	12	Moderate breeze. Moderate sea, SW swell. Cloudy.
	9	30 14 S	192 35	103	39	9	Fresh breeze. Moderate sea, SW swell. Overcast, rain, squally.
	10	29 22 S	194 32	114	287	13	Fresh breeze. Moderate sea. Partly cloudy.
	11	27 03 S	196 15	165	265	10	Fresh breeze. Moderate sea. Partly cloudy, squally, drizzling.
	12	25 07 S	197 38	138	349	15	Moderate breeze. Moderate sea. Overcast, squally.
	13	23 01 S	199 49	175	307	12	Fresh breeze to moderate gale. Moderate sea. Overcast.
	14	Rarotonga	....	117	.....	.....	Strong breeze. Rough sea. Overcast, squally. Anchored off Avarua, Rarotonga, at 9h15m a. m.
	15	Rarotonga	....	.....	.....	.....	Left Avarua at 1h50m p. m. Strong breeze. Rough sea. Partly cloudy.
	16	22 59 S	199 59	112	116	4	Light to fresh breeze. Moderately rough sea, SE swell. Partly cloudy.
	17	24 13 S	200 32	79	.....	.....	Gentle breeze. Moderately smooth sea. Partly cloudy, rain.
	18	24 37 S	202 58	136	327	18	Moderate to strong breeze. Moderate sea. Cloudy.
	19	25 28 S	206 04	176	358	13	Fresh to strong breeze. Rough sea. Cloudy, squally, rain.
	20	26 59 S	208 52	175	16	16	Strong breeze to moderate gale. Rough sea. Cloudy, squally, rain.
	21	28 11 S	211 54	177	338	11	Moderate gale. Rough sea. Partly cloudy, squally.
	22	29 02 S	214 47	160	332	17	Moderate gale to moderate breeze. Rough sea. Partly cloudy, squally.
	23	28 59 S	216 35	95	343	13	Gentle breeze to calm. Moderate sea, SW swell. Partly cloudy. Rudder stock splintered.
	24	28 58 S	216 31	4	305	5	Calm to gentle breeze. Smooth sea. Partly cloudy. Rigged jury steering gear.
	25	30 08 S	218 18	117	202	6	Moderate breeze to moderate gale. Smooth to rough sea, SW swell. Partly cloudy, drizzling.
	26	30 34 S	221 32	170	210	8	Moderate gale to fresh breeze. Rough sea. Cloudy, drizzling.
	27	29 51 S	224 30	159	298	13	Strong to fresh breeze. Rough sea. Partly cloudy, squally.
	28	28 22 S	227 14	169	293	12	Strong to moderate breeze. Moderate sea. Partly cloudy, squally.
	29	27 14 S	228 34	98	251	15	Gentle breeze. Moderate sea, SSE swell. Partly cloudy.
	30	28 58 S	228 25	104	230	13	Moderate breeze. Moderate sea, SSE swell. Cloudy.
	31	30 30 S	230 22	137	220	8	Moderate to strong breeze. Moderate sea, SSE swell. Overcast, misty.
Sep	1	31 36 S	233 14	162	213	6	Strong breeze to moderate gale. Rough sea. Overcast, rain, misty.
	2	32 01 S	235 25	114	204	6	Moderate gale to light air. Rough sea. Cloudy, misty, rain.
	3	31 42 S	236 34	61	36	16	Light air. Smooth sea, N swell. Partly cloudy. Under engine power.
	4	31 47 S	238 25	94	164	6	Light air to moderate breeze. Smooth sea. Cloudy.
	5	31 39 S	241 15	145	186	4	Moderate to light breeze. Smooth sea. Cloudy, foggy, misty.
	6	31 27 S	242 40	74	26	4	Calm to moderate breeze. Smooth sea, SW swell. Overcast, rain. Under engine power.
	7	31 39 S	245 54	166	182	12	Moderate breeze to moderate gale. Rough sea. Overcast, squally, misty.
	8	31 30 S	249 43	195	182	12	Moderate gale to gentle breeze. Rough sea. Overcast, squally, rain.
	9	31 32 S	251 33	94	186	9	Calm to strong breeze. Smooth sea, W swell. Overcast, rain.
	10	31 22 S	254 44	163	135	12	Strong breeze to moderate gale. Rough sea. Cloudy, squally, drizzling.
	11	30 36 S	257 46	163	303	6	Strong to gentle breeze. Moderately rough sea. Partly cloudy, squally, drizzling.
	12	29 38 S	259 12	95	31	2	Light breeze. Smooth sea, SW swell. Partly cloudy.
	13	27 50 S	259 02	109	246	14	Light to fresh breeze. Moderate sea, SW swell. Partly cloudy.
	14	25 17 S	258 25	156	205	14	Fresh breeze. Moderate sea, SW swell. Partly cloudy.
	15	22 07 S	258 14	190	236	15	Strong breeze. Rough sea. Partly cloudy, squally, rain.
	16	19 11 S	257 58	177	243	14	Strong breeze. Rough sea. Partly cloudy.
	17	16 11 S	257 41	181	256	14	Fresh breeze. Rough sea. Overcast.
	18	13 21 S	257 23	171	256	17	Fresh breeze. Moderate sea. Overcast.
	19	10 01 S	257 40	200	268	21	Fresh breeze. Moderate sea. Partly cloudy, squally, rain.
	20	7 29 S	258 40	164	258	14	Strong breeze. Rough sea. Cloudy, squally.
	21	5 19 S	259 58	151	269	16	Fresh breeze. Moderate sea. Cloudy, squally, rain.
	22	3 17 S	261 12	143	251	22	Moderate breeze. Moderate sea. Cloudy, rain, squally.
	23	1 33 S	262 01	115	267	27	Moderate breeze. Moderately smooth sea. Partly cloudy, squally.
	24	0 03 S	262 40	99	289	32	Gentle breeze. Smooth sea. Partly cloudy, squally.
	25	0 50 N	264 23	115	287	42	Moderate breeze. Moderate sea. Overcast, misty.

APIA TO BALBOA, CANAL ZONE—*Concluded.*

Date		Noon position Lat.	Noon position Long. E. of Gr.	Day's run	Current Dir.	Current Am't	Remarks
1921		° ′	° ′	*miles*	°	*miles*	
Sep	26	1 20 N	266 41	141	270	34	Moderate to fresh breeze. Moderate sea. Overcast, drizzling.
	27	2 01 N	268 22	109	293	22	Moderate breeze to light air. Moderate sea. Overcast. Sighted Culpepper Island.
	28	2 21 N	270 23	122	357	18	Moderate breeze. Moderate sea. Overcast, drizzling.
	29	2 44 N	272 14	113	87	3	Gentle breeze to light air. Smooth sea. Cloudy.
	30	2 24 N	273 42	90	213	9	Light air to moderate breeze. Smooth sea. Overcast, drizzling.
Oct	1	2 01 N	275 49	129	243	15	Fresh to light breeze. Moderate sea. Cloudy, drizzling.
	2	2 51 N	277 50	132	298	30	Moderate breeze. Moderate sea. Overcast, rain, lightning.
	3	3 50 N	279 50	132	352	27	Moderate breeze. Moderate sea. Overcast, rain, lightning.
	4	4 43 N	281 19	103	158	12	Moderate breeze to calm. Smooth sea. Cloudy, lightning, thunder. Under engine power.
	5	6 32 N	281 38	111	129	18	Light air. Smooth sea. Partly cloudy, lightning. Under engine power.
	6	7 52 N	281 06	86	105	10	Light air to calm. Smooth sea. Partly cloudy, lightning. Under engine power.
	7	Balboa	....	74	.....	.....	Calm. Smooth sea. Partly cloudy. Moored in Balboa Harbor at 10^h30^m a. m.

Total distance, 8,846 miles. Time of passage, 71.5 days. Average day's run, 123.7 miles.

BALBOA TO OLD POINT COMFORT.

Date		Noon position Lat.	Noon position Long. E. of Gr.	Day's run	Current Dir.	Current Am't	Remarks
1921		° ′	° ′	*miles*	°	*miles*	
Oct	20	Balboa	....	.....	.....	.....	Left dock at 7^h40^m a. m. under tow. Passed through Panama Canal.
	20	Cristobal	....	89	.....	.....	Arrived at Cristobal at 2^h40^m p. m. and proceeded at once to sea. Moderate breeze. Smooth sea. Partly cloudy.
	21	11 28 N	281 20	181	35	24	Fresh breeze to light air. Moderate sea. Partly cloudy, lightning. Under engine power.
	22	12 17 N	284 02	112	95	12	Light air to moderate breeze. Smooth sea. Partly cloudy, lightning. Under engine power.
	23	14 38 N	284 30	142	341	49	Fresh to light breeze. Moderate sea. Partly cloudy. Under engine power.
	24	17 21 N	284 47	163	344	39	Moderate breeze. Moderate sea. Partly cloudy, squally. Sighted Navassa Island light.
	25	19 01 N	285 32	109	346	7	Light breeze and calm. Smooth sea. Partly cloudy. Under engine power.
	26	20 40 N	286 05	104	175	15	Light to fresh breeze. Smooth sea. Partly cloudy, lightning. In Windward Passage. Sighted Cape Mayse.
	27	23 00 N	286 43	144	28	9	Moderate breeze to moderate gale. Smooth to rough sea. Partly cloudy, squally. Sighted Flat Cays.
	28	24 36 N	286 38	96	207	2	Moderate gale to strong breeze. Rough sea. Partly cloudy, squally, rain.
	29	24 57 N	285 25	70	249	11	Strong to gentle breeze. Rough, long rolling sea. Cloudy, squally, rain.
	30	26 41 N	284 41	111	332	20	Gentle to moderate breeze. Long rolling sea. Partly cloudy.
	31	28 38 N	284 59	119	214	15	Moderate breeze. Moderate sea, NE swell. Partly cloudy, squally, lightning. Seaweed.
Nov	1	31 06 N	285 15	148	283	9	Light breeze to moderate gale. Rough sea, S swell. Cloudy, squally, rain, lightning.
	2	33 14 N	286 18	139	125	9	Fresh gale to calm. Rough, long rolling sea. Squally, rain, lightning. Vessel hove to.
	3	33 44 N	286 04	32	238	16	Calm to strong breeze. Long rolling sea. Partly cloudy. Under engine power.
	4	35 11 N	286 11	88	141	18	Strong breeze to calm. Moderate sea, NE swell. Partly cloudy, squally. Under engine power.
	5	36 31 N	285 24	89	69	30	Fresh breeze to moderate gale. Rough sea. Partly cloudy. Under engine power.
	6[1]	Old Point Comfort		89	.....	.....	Gentle breeze. Moderate sea. Clear. Hove to off Old Point Comfort at 11^h a. m. At 1^h p. m. proceeded up Chesapeake Bay. Under engine power.

Total distance, 1,975 miles. Time of passage, 17.1 days. Average day's run, 115.5 miles.

[1] From November 6 to November 10 the *Carnegie* was swinging ship in Chesapeake Bay and at Solomons Island. Docked at Washington at 5^h20^m p. m., November 10.

TABLE 23.—*Summary of passages for Cruise VI of the Carnegie.*

Passage	Length of passage	Time of passage	Average day's run
	miles	*days*	*miles*
Washington to Solomons Island to Old Point Comfort.	220	2.6	....
Old Point Comfort to Dakar	4,217	34.3	123
Dakar to Buenos Aires	6,130	53.7	114
Buenos Aires to Jamestown, St. Helena	5,291	34.8	152
Jamestown, St. Helena, to Cape Town	3,170	20.9	152
Cape Town to Colombo	6,665	40.8	163
Colombo to Fremantle	5,650	38.5	147
Fremantle to Port Lyttelton	3,157	19.7	160
Port Lyttelton to Papeete	4,262	34.8	122
Papeete to San Francisco	6,099	47.3	129
San Francisco to Honolulu	2,222	14.7	151
Honolulu to Pago Pago	5,904	53.3	111
Pago Pago to Apia	90	0.7	....
Apia to Balboa	8,846	71.5	124
Balboa to Old Point Comfort	1,975	17.1	116
Old Point Comfort to Solomons Island to Washington.	220	2.6	....

Length of Cruise VI, 64,118 miles. Time at sea, 487.3 days. Average day's run, 132 miles.

TABLE 24.—*Final Summary for Cruises of the Carnegie, 1915–1921.*

Cruise	Length of passage	Time of passage	Average day's run
	miles	*days*	*miles*
IV, 1915–17	63,400	487	130
V, 1917–18	13,195	122	108
VI, 1919–21	64,118	487	132

Total length of cruises 1915 to 1921, 140,713 miles.
Total time at sea, 1,096 days. Average day's run, 128 miles.

The total number of days the *Carnegie* was in commission from March 5, 1915, to November 12, 1921, counting out the periods March 3, 1917, to December 4, 1917, when the vessel was at Buenos Aires, June 10, 1918, to October 8, 1919, when the vessel was at Washington and Baltimore, is 1,681 days. Since 1,096 days were spent at sea, the remaining days, 585, are to be ascribed to the time spent in ports, making shore observations and comparisons of instruments, computations, repairs, and outfitting. It is thus seen that about two-thirds of the time the vessel is in commission is spent at sea.

AUXILIARY OBSERVATIONS ON THE CARNEGIE.

In addition to observations in terrestrial magnetism, the scientific work on board the *Carnegie* included a regular program of observations in atmospheric electricity. An account of this work will be found in the special report on results in atmospheric electricity (see pp. 195–286).

Furthermore, observations were made regularly to determine the amount of atmospheric refraction by measuring the dip of the horizon with two dip-of-horizon measurers, by Carl Zeiss of Jena. The atmospheric refraction was measured also by means of sextant observations of the altitude of the Sun or of Venus when these celestial objects were near the zenith, measurements of the altitude being made alternately from the north and from the south horizons. A future special report will deal with this subject.

Meteorological observations were made to the following extent: Every 4 hours at sea the wind direction and force were noted. At the same time, temperatures of the sea-surface and of the air were recorded and readings of the wet-bulb thermometer were taken. In addition to these usual meteorological notes, special observations were made at Greenwich mean noon according to the forms prepared by the United States Weather Bureau for observations at sea. The ship's aneroids were controlled, from time to time, by special boiling-point observations at sea and by port comparisons with standard barometers, whenever opportunity afforded. Beginning at Dutch Harbor, Alaska, August 1915, special attention was also paid to occurrences of thunder at sea (see pp. 325 and 326, Vol. III, *Res. Dep. Terr. Mag.*).

The Greenwich mean noon observations, together with notes on more or less closely allied phenomena (storms, polar lights, unusual meteorological events, etc.), were regularly transmitted to the United States Weather Bureau for discussion along with the ocean data received by that bureau from other sources.

SPECIAL INVESTIGATIONS.

Numerous investigations have been made with reference to various matters which have come up, from time to time, in connection with the many interesting problems presented in the course of the scientific work on the *Carnegie*. Among these may be mentioned, (1) the observations with the auto roll-and-pitch recorder, to measure the amount of rolling and pitching of the vessel during magnetic observations; (2) measurements of the amount of rise and fall of the vessel by means of a sensitive statoscope; (3) determination of ocean currents by means of accurate navigation methods (see Abstracts of logs, pp. 144–170) and by means of the hydrogen-ion content of sea-water, devised by A. G. Mayor; (4) correcting geographic positions of outlying islands and supplying notes of geographical interest concerning remote and comparatively unknown places; (5) supplying information concerning icebergs sighted during the circumnavigation cruise in sub-Antarctic regions (see special report, pp. 171–174); and (6) measurement of temperature of sea-surface every hour during the circumnavigation cruise in sub-Antarctic regions, December 6, 1915, to April 1, 1916 (see special report, pp. 174–178).

REPORT ON ICEBERGS SEEN FROM THE CARNEGIE DURING THE SUB-ANTARCTIC VOYAGE, DECEMBER 6, 1915, TO APRIL 1, 1916.

Table 25 gives the details regarding icebergs seen from the *Carnegie* during her cruise around the south pole in sub-Antarctic regions, December 6, 1915, to April 1, 1916, from Lyttelton (New Zealand) to South Georgia to Lyttelton. Icebergs to the number of

TABLE 25.—*Report on Icebergs seen from the Carnegie, 1915–1916.*

No.	Date	Position of iceberg: Lat. South	Position of iceberg: Long. East of Gr.	Distance and direction from vessel	Dimensions: Height	Dimensions: Length	Wind: True Direction	Wind: Force	Temperature: Air	Temperature: Water	Remarks
	1915	° ′	° ′	*miles*	*feet*	*feet*	°		°*C*	°*C*	
1	Dec 18	60 13	209 17	0.1 S	15	50	141	4	0.2	−0.5	A small piece of rotten ice, irregular shape, blue and white in color.
2	Dec 19	60 14	211 41	0.1 S	10	80	219	5	−0.5	−0.2	Irregular shape, blue and white.
3	Do.	60 16	211 55	0.5 S	300	1.5 mi.	219	5	−0.5	−0.2	Flat-topped table berg with numerous cavities and arches.
4	Do.	60 17	212 09	1.0 S	300	1.0 mi.	219	5	−0.5	−0.2	Flat-topped table berg with thousands of small pieces to leeward.
5	Do.	60 17	212 31	0.2 N	200	3000	219	5	−0.5	−0.3	Table.
6	Do.	60 17	212 31	0.2 N	200	3000	231	6	−0.5	−0.3	Table.
7	Do.	60 18	212 47	0.1 N	150	600	231	6	−0.5	−0.3	Irregular.
8	Do.	60 18	212 47	0.1 N	150	600	231	6	−0.5	−0.3	Pinnacled.
9	Do.	60 18	212 47	0.1 N	150	600	231	6	−0.5	−0.3	Pinnacled.
10	Do.	60 18	212 47	0.1 N	30	100	231	6	−0.5	−0.3	Pinnacled.
11	Do.	60 18	212 47	0.1 S	50	100	231	6	−0.5	−0.3	Pinnacled.
12	Do.	60 19	212 58	1.5 S	50	200	231	6	−0.6	−0.3	Pinnacled.
13	Do.	60 20	213 03	1.5 S	50	200	231	6	−0.6	−0.2	Vertical strata, narrow overturned berg.
14	Do.	60 18	213 17	0.5 S	5	100	231	6	−0.6	−0.2	Low, flat iceberg, blue color.
15	Do.	60 18	213 28	0.2 N	10	50	231	6	−0.6	−0.3	Irregular.
16	Do.	60 20	213 35	2.0 S	50	200	231	6	−0.5	−0.3	Pinnacled top. From 9ʰ to 11ʰ passed several small pieces of various shapes and sizes.
17	Do.	60 22	214 09	3.5 S	300	200	231	6	0.0	0.0	Flat table iceberg, blue color.
18	Do.	60 22	214 22	3.0 S	100	800	231	6	0.2	0.0	Irregular.
19	Do.	60 19	215 02	1.0 N	250	200	231	6	0.2	0.0	Flat table collapsed. Two layers of snow formation on top. Upper part of berg well stratified.
20	Do.	60 21	215 04	1.5 S	60	100	231	6	0.2	0.0	Irregular.
21	Do.	60 18	215 26	2.0 N	60	100	253	6	0.2	0.0	Irregular.
22	Do.	60 24	215 29	3.5 S	115	1500	253	6	0.2	0.0	Table. Blue color.
23	Do.	60 18	215 33	3.0 N	100	200	253	6	0.2	0.0	Two separate pinnacles, blue color.
24	Do.	60 19	216 11	2.5 N	400	350	276	6	0.2	0.0	Pinnacled, blue. Sloping from highest point to water's edge. Snow formation on top.
25	Do.	60 21	216 37	1.0 N	80	200	276	6	0.2	0.0	Irregular.
26	Do.	60 24	217 09	2.0 S	200	600	287	6	0.2	0.0	Too dark and misty to see full outline.
27	Do.	60 20	217 23	3.0 N	200	250	287	6	0.1	0.0	Flat top, perpendicular sides.
28	Dec 20	60 23	219 07	3.2 N	260	500	343	5	0.2	0.1	One large irregular pinnacle and one small pinnacle, blue color.
29	Do.	60 29	219 50	1.0 S	15	10	343	5	0.2	0.0	One small pinnacle on each end, blue color.
30	Do.	60 30	219 57	1.0 S	20	30	343	5	0.2	0.0	One small pinnacle on each end, blue color.
31	Do.	60 34	220 07	4.5 S	200	150	343	5	0.2	0.0	Two bergs close together, pyramidal shape.
32	Do.	60 34	220 07	4.5 S	200	150	343	5	0.2	0.0	
33	Dec 21	60 18	225 11	1.5 N	200	800	343	6	0.1	0.0	One pinnacle on top.
34	Dec 22	59 47	230 52	4.6 S	200	800	338	4	2.6	2.0	Pyramidal shape. Blue color.
35	Do.	59 37	232 33	1.7 N	40	100	22	2	5.2	3.8	Two pinnacles and one obelisk.
36	Do.	59 37	232 33	1.7 N	40	100	22	2	5.2	3.8	One pinnacle and one pyramid.
37	Do.	59 45	232 52	5.5 S	350	600	338	8	5.0	3.0	One large table berg.
38	Dec 23	60 14	234 49	1.0 S	95	200	34	4	5.2	4.3	Irregular shape, blue color, hollowed out in the middle.
39	Dec 24	59 37	236 29	3.5 S	225	1425	326	5	3.5	4.7	Appeared as a black rocky island at first. Very precipitous, westerly side partly broken down.
	1916										
40	Jan 10	54 42	317 59	1.0 N	140	200	270	3	4.0	3.3	Large table inclined. Top crusted with snow.
41	Do.	54 41	318 02	1.0 N	...	...	270	3	4.1	3.4	About 90 small bergs, largest 4 feet high.
42	Do.	54 34	318 24	0.1 S	50	200	270	3	4.5	3.0	Irregular shape, hollowed out in middle.
43	Do.	54 26	318 32	5.0 N	60	250	270	3	4.6	3.5	One pinnacle.
44	Do.	54 27	318 45	0.1 N	35	150	270	3	4.8	3.6	One pinnacle and hollowed out in middle.
45	Do.	54 25	318 48	1.5 N	60	150	270	3	4.8	3.6	Irregular.
46	Jan 10	54 23	318 57	0.5 N	70	200	338	3	5.0	3.7	Irregular.
47	Do.	54 23	319 00	0.1 S	120	250	338	3	4.9	3.8	Inclined table.
48	Do.	54 08	320 16	0.2 S	120	600	349	4	3.5	2.8	Numerous pinnacles. Too foggy to see complete outline.
49	Jan 11	54 01	321 39	2.0 N	80	300	338	5	4.4	1.8	Table top.
50	Do.	54 03	321 42	0.2 N	70	250	338	5	4.4	1.8	Irregular table.
51	Do.	54 03	321 42	0.2 N	70	250	338	5	4.4	1.8	Inclined table.
52	Do.	54 03	321 44	0.1 N	50	200	338	5	4.4	1.8	Irregular.
53	Do.	54 03	321 47	0.5 S	50	100	338	5	4.3	1.8	Table top. Off northwest end of South Georgia.
54	Do.	54 03	321 47	0.5 S	50	150	338	5	4.3	1.8	Table top. Off northwest end of South Georgia.
55	Do.	54 03	321 47	0.5 S	100	200	338	5	4.3	1.8	Table top. Off northwest end of South Georgia.
56	Jan 15	54 17	325 45	3.0 S	100	300	298	8	3.2	2.0	Table top. Pinnacle at one end.
57	Do.	54 12	325 47	1.8 N	80	200	298	8	3.2	2.0	Sloping down on two sides.
58	Do.	54 11	326 41	5.0 N	400	800	264	6	3.4	2.2	Pinnacle at one end.
59	Do.	54 23	327 38	6.0 S	200	600	264	6	3.4	2.0	Table top with two pinnacles.
60	Do.	54 18	328 05	0.2 S	40	100	264	6	3.4	2.0	Two pinnacles.
61	Do.	54 16	328 16	1.8 N	122	400	264	6	3.2	3.2	Table top crusted with snow.
62	Do.	54 15	328 17	2.5 N	65	80	264	6	3.2	2.0	Sloping berg.
63	Do.	54 16	328 26	3.5 N	80	120	264	6	3.0	2.0	Irregular.
64	Jan 16	54 30	330 30	1.5 N	120	800	0	4	2.2	2.2	Table top, blue. Numerous small pieces drifting to leeward.
65	Do.	54 36	331 18	2.0 N	100	300	34	5	2.7	2.0	Irregular, blue.
66	Do.	54 40	331 22	1.5 S	75	180	34	5	2.7	2.0	Pinnacle at one end.
67	Do.	54 42	332 25	0.2 S	140	3.0 mi.	326	4	3.5	2.1	Irregular.

TABLE 25.—*Report on Icebergs seen from the Carnegie, 1915–1916*—Concluded.

No.	Date	Position of iceberg: Lat.	Position of iceberg: Long. East of Gr.	Distance and direction from vessel	Dimensions: Height	Dimensions: Length	Wind: True direction	Wind: Force	Temperature: Air	Temperature: Water	Remarks
	1916	° ′	° ′	*miles*	*feet*	*feet*	°		° *C*	° *C*	
68	Jan 17	54 34	334 38	0.3 N	25	100	338	5	3.5	2.0	Low ice, hollowed out in middle.
69	Jan 18	54 34	341 13	0.5 S	30	100	287	7	4.1	2.7	One pinnacle, hollowed out in middle, blue color.
70	Jan 19	54 34	343 40	4.0 S	150	250	276	2	2.9	3.0	One pinnacle at one end, blue color.
71	Do.	54 28	343 53	1.5 N	220	300	264	2	3.0	2.8	One large and one small pinnacle.
72	Do.	54 30	345 16	1.3 S	30	120	264	4	3.8	2.3	Low flat berg with numerous small pieces.
73	Do.	54 30	345 16	1.3 S	40	120	264	4	3.8	2.3	High pinnacle at one end.
74	Do.	54 25	345 21	4.0 N	200	300	264	4	3.8	2.8	Irregular, pinnacled, blue.
75	Do.	54 32	345 36	4.0 S	250	350	264	4	3.5	2.4	High at center, sloping down to three sides. Pinnacle at one end, b
76	Do.	54 31	346 30	4.5 S	200	400	264	4	3.0	2.6	Large table with numerous small pieces, blue.
77	Jan 20	54 26	347 26	1.4 S	30	150	259	4	2.4	2.0	Table top.
78	Do.	54 25	347 55	0.5 S	30	100	270	4	1.9	1.8	Low flat berg.
79	Jan 21	54 15	357 00	3.0 N	300	5.0 mi.	315	7	2.2	0.5	Table top. Located at a distance by a white blink in the fog ba
80	Do.	54 15	357 00	Ice stream	......	......	......	......	......	......	Passed through what appeared to be an ice stream. Several b sighted to southward, fog preventing details.
81	Jan 22	53 37	358 45	4.0 N	300	3.0 mi.	267	5	1.1	0.5	Table with snow on top.
82	Do.	53 44	358 48	3.0 S	350	1.0 mi.	267	5	1.1	0.5	Table top with numerous pieces to leeward.
83	Do.	53 38	359 52	2.7 N	300	1.0 mi.	267	5	1.2	0.6	Table top, very regular outline.
84	Do.	54 10	1 55	1.5 S	120	500	267	6	2.7	1.0	Table top, very regular outline.
85	Do.	54 27	2 14	7.0 S	300	350	267	6	2.6	1.0	Irregular.
86	Do.	54 23	2 35	1.0 S	150	4.5 mi.	267	6	2.2	0.8	Table top, very regular outline.
87	Do.	54 26	2 42	4.0 S	50	200	267	6	2.1	0.8	Sloping table.
88	Do.	54 30	3 21	4.0 S	100	200	259	7	1.8	0.2	Table top, off west end of Lindsay Island.
89	Do.	54 30	3 21	4.0 S	120	250	259	7	1.8	0.2	Pinnacled, off west end of Lindsay Island.
90	Do.	54 26	3 29	1.0 S	50	300	259	7	1.6	0.2	Table top, off west end of Lindsay Island.
91	Do.	54 26	3 29	1.0 S	50	300	259	7	1.6	0.2	Wrecked table off west end of Lindsay Island.
92	Do.	54 26	3 29	1.0 S	50	300	259	7	1.6	0.2	Wrecked table off west end of Lindsay Island.
93	Do.	54 26	3 29	1.0 S	50	300	259	7	1.6	0.2	Pinnacled. Off west end of Lindsay Island.
94	Do.	54 28	3 36	3.0 S	100	200	259	9	1.5	0.2	Irregular. Off east end of Lindsay Island.
95	Do.	54 28	3 36	3.0 S	100	200	259	9	1.5	0.2	Irregular. Off east end of Lindsay Island.
96	Do.	54 28	3 36	3.0 S	100	200	259	9	1.5	0.2	Numerous small pieces all over the sea. Off east end of Lin Island.
97	Jan 23	53 55	3 15	2.0 S	300	1.0 mi.	304	8	1.5	0.2	Table top.
98	Do.	53 36	5 06	2.0 S	170	250	267	6	1.8	1.0	Irregular.
99	Do.	53 30	6 15	1.4 N	80	180	292	4	2.4	1.0	Two pinnacles.
100	Do.	53 30	6 50	0.1 S	8	40	332	4	1.3	1.0	Three pinnacles.
101	Jan 24	53 44	9 32	4.0 S	100	250	276	4	2.0	1.0	Inclined table.
102	Do.	53 35	9 41	6.0 N	150	3000	276	4	2.0	1.0	Regular table.
103	Do.	53 35	10 42	10.7 N	150	3000	276	4	2.5	1.0	Table top.
104	Do.	53 50	12 09	2.4 N	100	300	298	5	1.7	0.4	Pinnacled at one end.
105	Jan 25	53 56	13 16	0.8 S	160	500	309	5	1.2	0.1	Table top.
106	Do.	53 54	13 19	3.0 N	100	300	309	5	1.2	0.0	Pinnacled at one end.
107	Do.	53 56	13 24	0.5 N	100	800	309	5	1.2	0.0	Large flat berg crusted with snow. Numerous pieces to leeward
108	Do.	53 53	14 02	6.0 N	500	600	321	5	1.0	0.2	Three large pinnacles.
109	Do.	53 54	14 07	5.0 N	350	500	321	5	1.0	0.1	Large pinnacle at one end.
110	Do.	54 12	15 12	5.0 S	150	1400	321	5	1.7	0.2	Table top
111	Do.	54 02	15 14	4.5 N	175	300	321	5	1.7	0.3	Irregular. Hollowed out in middle.
112	Do.	54 10	15 52	0.5 N	20	50	309	5	2.1	1.0	Two small pinnacles.
113	Do.	54 16	15 56	5.0 S	70	150	309	5	2.0	1.0	A pinnacle at one end.
114	Do.	54 14	16 14	0.2 S	70	3000	309	5	1.9	1.0	Table top. A number of small pieces to leeward.
115	Do.	54 10	16 41	7.0 N	200	250	309	5	1.7	1.0	Table top.
116	Do.	54 10	16 41	7.0 N	150	200	309	5	1.7	1.0	Pyramid.
117	Do.	54 18	17 35	4.5 N	350	700	309	5	0.7	0.3	A large flat berg, terraced at one end.
118	Jan 26	54 25	18 45	3.0 N	80	300	304	5	0.9	0.2	Table top.
119	Do.	54 33	19 20	2.0 S	50	150	304	5	0.9	0.4	Table top, sloping to water's edge on one side.
120	Do.	54 35	19 37	2.5 S	100	280	304	5	0.9	0.5	Pinnacle at one end.
121	Do.	54 31	19 40	2.0 N	110	200	304	5	1.0	0.5	Hollowed out in middle.
122	Do.	54 28	19 56	5.0 N	256	700	315	5	1.2	0.8	Table top, terraced at one end.
123	Do.	54 29	20 26	2.5 N	275	600	315	5	1.5	0.8	Two separate tables, about 50 feet apart, apparently joined bel water line.
124	Do.	54 36	21 05	5.0 S	70	200	338	5	1.8	1.0	Irregular, sloping down to water at one end.
125	Do.	54 38	21 29	0.8 N	110	180	338	5	2.0	1.0	One very tall slender pinnacle.
126	Do.	54 32	21 48	4.0 S	160	250	338	5	2.0	1.0	Three high pinnacles.
127	Do.	54 30	21 51	2.0 S	80	900	338	5	2.0	1.0	Table top.
128	Do.	54 18	22 12	9.5 N	400	300	338	5	2.0	1.0	One pinnacle.
129	Do.	54 21	23 01	4.0 N	280	600	349	5	1.7	1.0	Pyramid, sloping down on two sides.
130	Do.	54 18	23 55	3.0 N	100	300	349	6	1.2	1.0	Irregular.
131	Jan 27	54 16	25 48	0.3 N	70	200	349	6	1.4	0.9	Irregular, a number of small pieces to leeward.
132	Jan 28	53 39	31 09	1.0 S	60	150	315	5	2.2	1.3	Irregular.
133	Mar 1	58 31	109 06	1.2 W	60	80	270	9	2.0	2.2	Irregular with large round top.

133 were recorded and described. Many others were seen at night and during the day at distances too great for accurate measurements. The distances from the vessel of those measured ranged from one-eighth mile to 10 miles, and these distances were estimated by the usual navigation methods, noting the change in the bearing or direction of the iceberg with the corresponding change in time and in the distance the vessel had traversed. The height and length of the iceberg were computed from sextant angles in connection with the estimated distance of the iceberg from the observer. The largest iceberg sighted was 300 feet in height and 5 miles long. The highest one sighted was 500 feet in height.

The positions of the icebergs have been corrected for chronometer error as determined after arrival at Lyttelton at the end of the trip.

For further information regarding conditions encountered on this sub-Antarctic voyage, and for explanation of symbols used in Table 25, see the narrative of the trip, pages 139 to 143, and the report on sea surface-temperatures and meteorological observations made on the *Carnegie* during her sub-Antarctic cruise, pages 174 to 178. The majority of the icebergs were white in color. When the iceberg was definitely blue in color, it is noted in the remarks column.

SEA-SURFACE TEMPERATURE AND METEOROLOGICAL OBSERVATIONS DURING THE SUB-ANTARCTIC CRUISE, 1915–1916.

Table 26 contains the results of sea-surface temperature and meteorological observations made on board the *Carnegie* during her sub-Antarctic cruise, December 6, 1915 to April 1, 1916, from Lyttelton (New Zealand) to South Georgia and Lyttelton. Reports that have thus far come from this region are few and incomplete, and as the part of the Southern Ocean traversed is the scene of such rapid and extreme changes in meteorological conditions, any additional information on the subject will be of interest.

The *Carnegie* made a complete circumnavigation of the globe from west to east, mainly between the parallels of latitude 50° and 60° south, in one season, the southern summer of 1915–16, during which Sir Ernest Shackelton's expedition was meeting with such serious reverses. The meteorological observations made by the two parties of his expedition and those obtained on the *Carnegie* are especially valuable because they are contemporaneous records of the conditions prevailing in different parts of the southern regions at that time.

The *geographic positions* given in the table are the corrected noon positions, all resulting from good observations. The longitudes have been corrected for an error of 22 seconds in the chronometers at the end of a four-months' cruise.

The various symbols used to describe the *conditions of the weather* show the changes that took place in the weather during the day, given in chronological order; they have the following significance:

b. Clear blue sky.
c. Cloudy weather.
d. Drizzling, or light rain.
f. Fog, or foggy weather.
g. Gloomy, or dark stormy-looking weather.
h. Hail.
l. Lightning.
m. Misty, or hazy weather.
o. Overcast.
p. Passing showers of rain.
q. Squally weather.
r. Rainy weather, or continuous rain.
s. Snow, snowy weather, or snow falling.
t. Thunder.
u. Ugly appearance, or threatening weather.
v. Variable weather.
w. Wet, or heavy dew.

The true direction from which the wind was blowing and the force are next tabulated, the different directions being the important shifts in the wind during the day, given in chronological order, the day being reckoned from midnight to midnight throughout the

3

table. The Beaufort scale is used in denoting the *force of the wind*, the figures having the following significance:

0. Calm	5. Fresh wind.	9. Strong gale.
1. Light air.	6. Strong wind.	10. Whole gale.
2. Light breeze.	7. Moderate gale.	11. Storm.
3. Gentle breeze.	8. Fresh gale.	12. Hurricane.
4. Moderate breeze.		

The *barometric pressure* was scaled from the various sheets of an aneroid barograph and corrected by comparisons with readings made daily at Greenwich mean noon on a closed cistern-type mercurial barometer. Twenty readings were always taken on the mercurial barometer, ten highs and ten lows. These readings were reduced to standard, corrected for temperature, and reduced to sea-level. In the next two columns are tabulated the *amount and duration of change* between a high barometric pressure and the next low barometric pressure, or a low and the next high, as the case may be. The change is considered positive if the mercury is rising or pressure is increasing. Considering these changes in connection with the changes as indicated in the column containing the "true direction of the wind," it will be noticed that almost invariably during the entire four months, with a high and decreasing barometric pressure a northerly wind shifted to the west, blowing a gale, then shifted to the southwest as the barometric pressure began to increase and blew hard if the rise was rapid.

A thermograph, placed in the usual type of open-air meteorological shelter-house on deck, kept a continuous record of the *temperature of the air*. Wet-bulb and dry-bulb thermometers were kept in the same shelter-house and were read every four hours during both day and night. The results given in the "*Relative humidity*" column were taken from "Landolt-Börnstein, Physikalisch-Chemische Tabellen," using the temperature of the dry bulb and the difference between wet and dry bulb.

The *temperature of the sea-water* was recorded every hour while at sea, both day and night. A small canvas bucket was used, water was taken from about 2 feet under the surface, and the temperature was read with the thermometer in the water. A plain glass thermometer divided into degrees centigrade and without guard was used. In the next column headed "$T_a - T_s$" is given the *difference in centigrade degrees between the air temperature and that of the sea*, the difference being reckoned positive if the air is warmer than the water and negative if it is colder.

The results of *observations for ocean current*, as the continuous rough sea caused the log to overrun, are not very reliable. The *true directions towards which the current was flowing* are given and the amount column gives the *number of nautical miles per day*. All directions are given in degrees, reckoned from 0° at north, through 90° at east, 180° at south, and 270° at west.

TABLE 26.—*Sea-Surface Temperature and Meteorological Observations on the Carnegie's Sub-Antarctic Cruise.*

Date	Noon position: Lat. South	Noon position: Long. East of Gr.	Weather	Wind direction (true, in degrees)	Force: Min.	Force: Max.	B. P. 700 mm. +: Min.	B. P. 700 mm. +: Max.	B. P. 700 mm. +: Mean	B. P. change: Am't.	B. P. change: Dur.	Rel. hum.	Air temp.	Sea temp.	T_a-T_s	Ocean current: Direction	Ocean current: Am't
1915	° ′	° ′					mm	mm	mm	mm	h	p. ct.	°	°	°	°	miles
Dec 6	Lyttelton		boc	56	5	5	....	65.1	....	......	..	96	13.4	13.0	+0.4	...	..
7[1]	46 14	174 44	odc	56 to 11 to 191	2	5	42.3	57.3	49.8	......	..	96	12.5	11.2	+1.3	318	12
8	47 47	176 23	odqc	214 to 236 to 248 to 214	5	9	39.9	42.3	41.1	−25.2	56	96	9.0	9.9	−0.9	344	16
9[2]	49 10	178 41	dqocp	214	4	9	42.3	48.7	45.5	......	..	90	8.8	9.5	−0.7	3	15
9[3]	50 11	181 42	oqpc	214 to 225	4	7	48.8	51.8	50.3	+11.9	52	87	7.5	9.4	−1.9	321	18
10	51 15	184 01	ocdmr	225 to 292 to 338 to 248 to 202	2	6	45.9	51.8	48.8	− 5.9	19	88	9.0	9.4	−0.4	343	14
11	53 16	186 54	mdcqpr	214 to 248 to 292 to 338	2	7	42.5	50.9	46.7	+ 5.0	18	89	9.2	10.1	−0.9	317	19
12	53 54	188 53	odc	338 to 270 to 202 to 158 to 214	2	6	39.7	46.3	43.0	−11.2	19	88	6.5	9.0	−2.5	44	15
13[4]	54 30	191 44	ocqlr	214 to 225 to 202	4	5	46.0	46.8	46.4	......	..	82	6.5	8.5	−2.0	351	13
14	55 18	194 51	cqpoq	202 to 180 to 202 to 191 to 202	2	6	45.8	53.6	49.7	+13.9	64	84	4.4	6.8	−2.4	293	11
15	56 00	197 38	obcd	202 to 292 to 0 to 22	1	6	40.8	52.9	46.8	......	..	88	4.1	5.2	−1.1	326	14
16	57 10	201 58	odmr	22 to 338 to 292	6	10	26.3	40.8	33.6	−27.3	36	99	4.7	3.2	+1.5	209	24
17	58 58	205 25	omrd	292 to 338 to 315 to 338	5	5	22.8	28.3	25.6	+ 2.0	17	94	2.2	0.5	+1.7	326	16
18[5]	60 18	208 50	omds	349 to 34 to 79 to 169	3	5	13.9	22.8	18.4	−14.4	40	98	0.2	−0.2	+0.4	307	16
19[6]	60 19	214 18	ms	158 to 169 to 191 to 292	5	6	14.3	21.3	17.8	+ 7.4	27	96	−0.2	−0.2	0.0	259	18
20[7]	60 30	220 26	mso	292 to 349	4	6	19.7	20.9	20.3	− 1.6	6	96	0.1	0.0	+0.1	232	15
21[8]	60 14	226 31	mso	349 to 338	5	8	19.7	31.3	25.5	......	..	98	0.8	0.6	+0.2	219	27
22[7]	59 40	232 08	obcd	338 to 22 to 0 to 338 to 22	2	5	31.3	40.3	35.8	+20.6	65	94	4.0	2.6	+1.4	202	22
23[7]	60 43	236 25	ordmf	34 to 45 to 22	3	6	32.8	40.3	36.6	......	..	94	4.6	3.7	+0.9	165	14
24[7]	59 59	236 03	fo	22 to calm to 259 to 292 to 225	0	7	30.1	35.3	32.7	−10.2	31	94	4.2	4.1	+0.1	95	18
25	59 12	242 17	odr	248 to 225 to 259	6	7	35.3	39.5	37.4	+ 9.4	35	91	4.2	4.4	−0.2	297	8
26	59 07	249 20	ordmbc	248 to 270 to 349	6	6	36.8	38.3	37.6	......	..	93	4.8	4.5	+0.3	248	23
27	59 10	256 31	odq	349 to 338 to 304	6	7	22.9	26.7	24.8	−16.6	37	90	5.1	4.8	+0.3	215	24
28	58 48	262 52	oqbc	304 to 281 to 270	5	6	25.9	33.8	29.8	......	..	87	5.4	5.4	0.0	225	21
29	58 47	268 30	ordbc	270 to 248 to 236 to calm	0	5	33.8	42.9	38.4	+20.0	61	89	5.6	5.7	−0.1	271	12
30	58 49	271 33	ocdb	281 to 292 to 202 to 169 to 259	1	3	40.8	42.7	41.8	......	..	76	5.4	5.9	−0.5	269	6
31	58 56	274 15	bcwb	338 to 11 to 349	1	4	41.7	42.5	42.1	......	..	85	5.4	6.4	−1.0	233	10
1916																	
Jan 1	59 17	279 59	bcdmp	0 to 11 to 22 to 11	4	6	39.8	42.7	41.2	......	..	87	7.0	6.0	+1.0	251	13
2	60 04	285 30	c-lmfr	338 to 22 to 0	4	5	38.9	39.6	39.2	− 4.0	98	96	6.1	5.6	+0.5	230	17
3	59 41	292 00	mrdb	11 to 22	3	5	38.9	41.3	40.1	+ 2.4	10	94	6.2	5.2	+1.0	215	22
4	60 09	294 45	mowfd	22 to 56 to 90 to calm to 292	0	3	33.3	38.9	36.1	......	..	96	4.4	4.4	0.0	99	34
5	59 16	297 18	dobcb	281 to 326 to 338	4	4	33.3	48.9	41.1	− 8.0	33	92	5.6	4.0	+1.6	299	28
6	58 42	302 25	bodr	326 to 11 to 338 to 11 to 326	4	9	40.3	50.4	45.4	+17.1	35	94	4.2	3.0	+1.2	142	17
7	57 44	307 37	omb	326 to 292 to 270 to 180	4	9	40.1	....	....	−10.3	16	92	4.4	2.5	+1.9	219	9
							....	51.3	45.7	+11.2	22	..	....	....	.....	...	..
8	56 26	312 47	cdobc	292 to 326 to calm	0	5	47.3	51.1	49.2	......	..	94	4.8	3.2	+1.6	201	14
9	55 32	315 22	oc	Calm to 158 to calm to 315 to 326	0	3	47.1	52.4	49.8	− 4.2	28	94	4.8	4.5	+0.3	243	7
10[9]	54 24	318 53	odfd	315 to 270 to 338 to 0 to 315	3	4	48.8	54.6	51.7	+ 7.5	32	96	4.2	3.6	+0.6	200	13
11[10]	54 04	321 30	fmdrbc	349 to 315 to 225 to 158 to 112	2	5	38.5	48.8	43.6	......	..	94	4.4	2.8	+1.6	139	10
12[11]	54 08	323 30	oqmf	112 to 135 to calm	0	3	36.9	40.6	38.8	−17.7	40	97	2.8	2.9	−0.1	312	8
13	South Georgia		....	......	..	..	....	40.9	....	+ 4.0	27	..	....	....	....	...	..
					..	..	35.4	....	38.2	− 5.5	9	..	....	....	....	...	..

1916		° ′	° ′					mm	mm	mm	mm	h	p. ct.	°	°	°	°	miles
Jan	14	South	Georgia	uqp	315	8	9	32.5	38.3	35.4	+ 2.9	9	90	3.9	2.8	+1.1	...	..
	15[7]	54 16	327 11	odbem	315 to 270 to 225	2	9	31.2	49.9	40.6	− 7.1	26	94	3.0	2.2	+0.8	268	5
	16[7]	54 40	331 35	odmf	349 to 22 to 315 to 270 to 315	3	5	45.5	49.9	47.7	+18.7	20	97	2.8	2.0	+0.8	181	6
	17[7]	54 36	335 52	mf	315 to 292 to 338	4	8	38.3	45.5	41.9	......	..	98	4.2	2.7	+1.5	194	6
	18[7]	54 33	341 39	mdf	338 to 349	2	8	36.3	....	....	−13.6	50	98	3.6	2.9	+0.7	212	7
						..	..	....	38.5	37.4	+ 2.2	11	..	....	....	.....	...	..
	19[7]	54 30	344 52	mdof	281 to 270	2	4	36.3	47.6	42.0	− 2.2	14	98	3.3	2.4	+0.9	237	12
	20[7]	54 18	349 59	omf	270 to 338 to 0 to 349	4	6	47.6	50.7	49.2	+14.4	41	98	2.6	1.7	+0.9	236	24
	21[12]	54 20	356 35	ofdmbc	338 to 315 to 270	4	7	47.5	52.3	49.9	− 3.2	15	98	1.8	1.0	+0.8	227	29
	22[12]	54 00	1 41	bcmd	270 to 304	5	9	52.3	57.7	55.0	+10.4	23	90	2.0	0.6	+1.4	181	15
	23[7]	53 33	5 33	mdos	304 to 292 to 338 to 11	..	..	51.7	....	....	− 6.0	14	..	....	....	.....	...	..
						3	9	46.5	56.1	51.3	+ 4.4	9	90	2.2	0.6	+1.6	232	7
	24[7]	53 42	9 49	odmfs	0 to 338 to 281 to 315	3	5	40.7	....	....	−15.4	19	89	2.0	0.8	+1.2	241	17
						..	..	....	42.5	41.6	+ 1.8	15	..	....	....	.....	...	..
	25[7]	54 08	15 34	sobcs	315 to 326 to 315	5	5	39.1	41.3	40.2	− 3.4	8	92	1.4	0.5	+0.9	260	15
	26[7]	54 30	21 18	cbcod	315 to 338 to 0	5	6	40.0	41.9	41.0	+ 2.8	28	92	1.4	0.6	+0.8	225	15
	27[7]	54 16	26 22	cdfms	349 to 0 to 281 to 225	2	6	30.5	39.3	34.9	−11.4	32	98	1.0	1.0	0.0	229	31
	28[7]	53 40	30 57	osc	236 to 248	5	6	31.8	43.7	37.8	......	..	86	1.8	1.5	+0.3	198	22
	29	52 40	36 39	csodfq	259 to 304 to 349 to 326	6	10	35.8	44.8	40.3	+14.3	34	90	2.8	2.4	+0.4	202	26
	30	52 45	39 12	qrmbc	326 to 0 to 326 to 349	6	10	30.1	35.8	33.0	−14.7	24	94	3.5	2.5	+1.0	142	21
	31	51 38	43 05	ocmr	326 to 259 to 326	4	8	35.3	47.7	41.5	+17.6	38	90	3.5	2.5	+1.0	179	23
Feb	1	49 42	47 15	qroc	326 to 292	6	10	43.7	49.3	46.5	− 4.0	6	94	5.0	3.9	+1.1	19	19
	2	48 36	50 59	ocbc	292 to 259 to 236 to 270	4	6	48 9	57.3	53.1	......	..	86	5.2	4.6	+0.6	179	12
	3	48 33	55 13	bcdo	259 to 281 to 326	4	6	56.7	59.0	57.8	......	..	85	5.8	5.2	+0.6	301	22
	4	48 40	59 57	o	326 to 11	4	6	57.3	59.8	58.6	+16.1	79	91	6.8	6.0	+0.8	275	16
	5	49 01	63 44	odmrb	338 to 304 to 214 to 259	3	7	55.5	....	....	− 4.3	17	93	6.1	5.2	+0.9	344	14
						..	..	....	64.0	59.8	+ 8.5	19	..	....	....	.....	...	..
	6[14]	49 34	67 12	bcomd	259 to 349 to 22 to 292	8	7	48.3	63.6	56.0	......	..	89	5.3	4.8	+0.5	314	8
	7	51 01	70 48	odqrm	270 to 292 to 248 to 202	7	10	38.3	48.3	43.3	−25.7	42	86	4.0	3.8	+0.2	352	21
	8	52 07	74 57	obcspq	202 to 225 to 180	6	9	44.6	50.7	47.6	......	..	87	2.8	3.1	−0.3	5	21
	9	51 04	77 52	bcodsq	270 to 248 to 225 to 248	5	7	50.7	55.6	53.2	+17.3	44	88	3.7	4.3	−0.6	314	13
	10	49 47	80 29	odrmq	281 to 315 to 0 to 56 to 90 to 158	3	9	34.6	51.7	43.2	−21.0	24	92	3.5	5.0	−1.5	237	17
	11	47 10	83 39	oqrd	214 to 236 to 202 to 225	8	8	45.3	52.1	48.7	......	..	85	5.6	7.8	−2.2	247	24
	12	44 06	86 30	qrd	225 to 214 to 225 to 202	7	8	52.1	59.3	55.7	......	..	82	7.5	9.8	−2.3	230	17
	13	41 15	88 32	qcdo	180 to 202 to 236 to 281	3	8	59.3	65.3	62.3	......	..	79	11.2	12.8	−1.6	203	28
	14	38 18	90 26	oc	315 to 304 to 315	5	6	65.1	66.6	65.8	......	..	77	15.2	15.4	−0.2	198	21
	15	35 48	93 10	ocbcd	315 to 304 to 292 to 225 to 146	3	5	65.9	67.3	66.6	......	..	76	18.1	17.6	+0.5	189	23
	16	34 32	95 58	ocb	146 to 124 to 135	3	4	67.3	71.8	69.6	......	..	70	16.3	17.8	−1.5	265	27
	17	34 59	95 34	oc	135 to 112 to 101 to 112	3	5	71.9	73.1	72.5	+38.5	163	78	15.6	17.2	−1.6	301	8
	18	36 10	95 23	obc	101 to calm to 101 to 45 to calm to 68	0	8	67.3	71.9	69.6	......	..	74	16.5	16.8	−0.3	358	8
	19	36 08	97 10	bcoc	Calm to 79 to 135 to 180 to calm	0	1	65.5	67.3	66.4	......	..	77	20.0	17.4	+2.6	243	10
	20	37 26	97 30	ocbcq	Calm to 292 to 338 to 292 to 248 to 191	0	5	61.3	65.5	63.4	−11.8	84	86	15.6	16.0	−0.4	315	9
	21	39 48	99 11	qdbco	214 to 248	4	7	61.5	67.3	64.4	+ 6.0	22	77	14.0	13.7	+0.3	350	21
	22	42 18	100 26	bcodo	248 to 270	5	7	55.3	66.8	61.0	......	..	86	12.6	12.5	+0.1	35	25
	23	46 07	101 33	qdmr	259 to 270 to 281 to 248 to 281	4	8	48 1	55.3	51.7	−19.2	41	94	9.6	9.4	+0.2	63	42
	24	47 52	102 01	oc	259 to 281 to calm to 191 to 169	0	4	52.1	55.3	53.7	+ 7.2	33	92	7.0	6.5	+0.5	59	31
	25	47 49	103 39	ocbc	169 to 146 to 225 to 270	2	5	43.3	55.3	49.3	......	..	78	6.5	6.8	−0.3	354	6
	26	49 58	104 51	odqh	270 to 236 to 259	5	9	34.9	43.3	39.1	−20.4	43	87	5.1	5.6	−0.5	26	29
	27	52 32	106 34	qdho	248 to 236 to 248	6	10	35.3	43.0	39.2	+ 8.1	29	88	3.8	4.5	−0.7	22	30
	28[15]	54 33	107 33	qdofmr	248 to 270 to 292 to 236	3	6	25.6	42.8	34.2	......	..	97	3.9	4.0	−0.1	46	25
	29[15]	57 08	108 29	qsdrh	248 to 259 to 270	7	10	24.6	....	....	−18.4	28	86	2.9	3.2	−0.3	177	23
						..	..	....	28.1	26.4	+ 3.5	9	..	....	....	.....	...	..

TABLE 26.—*Sea-Surface Temperature and Meteorological Observations on the Carnegie's Sub-Antarctic Cruise*—Concluded.

Date	Noon position: Lat. South	Noon position: Long. East of Gr.	Weather	Wind direction (true, in degrees)	Force: Min.	Force: Max.	B. P. 700 mm. +: Min.	B. P. 700 mm. +: Max.	B. P. 700 mm. +: Mean	B. P. change: Am't.	B. P. change: Dur.	Rel. hum.	Air temp.	Sea temp.	T_a-T_s	Ocean current: Direction	Ocean current: Am't
1916	° ′	° ′					*mm*	*mm*	*mm*	*mm*	*h*	*p. ct.*	°	°	°	°	*miles*
Mar 1[16]	59 15	110 00	sq	259 to 236 to 169 to 158	5	9	17.6	28.1	22.8	−10.5	20	94	2.0	2.4	−0.4	30	20
2[15]	56 54	112 23	sqdhbc	180 to 202 to 180 to 202	6	7	28.1	51.7	39.9	......	..	89	3.0	3.5	−0.5	267	23
3[17]	53 45	113 41	oc	214 to 191 to 236 to 281	4	6	51.7	57.3	54.5	+39.7	57	82	3.5	4.2	−0.7	172	15
4	51 30	116 26	ocmdq	304 to 338 to 11 to 338 to 292	4	8	42.1	55.6	48.8	......	..	92	5.1	5.5	−0.4	198	16
5[15]	49 13	120 16	qdhr	292 to 270	7	9	41.5	45.0	43.2	−15.8	39	83	6.2	7.6	−1.4	136	33
6[18]	46 02	122 55	qchdr	281 to 270 to 315 to 349	7	10	39.8	47.5	43.6	+ 6.0	27	88	8.8	9.7	−0.9	145	16
7	45 09	125 08	qrhdl	349 to 315 to 281 to 292	9	11	36.3	....	....	−11.2	15	88	9.8	10.8	−1.0	19	8
					..	..	....	48.9	42.6	+12.6	18	..	....	....	.....	...	..
8[15]	44 58	126 01	qrlh	338 to 315 to 292	6	10	45.1	52.3	48.7	− 3.8	7	83	8.2	10.8	−2.6	00	7
9	44 11	126 34	qrchd	292 to 270 to 259 to 315	5	8	51.7	60.1	55.9	+15.0	40	76	9.9	10.8	−0.9	349	12
10	41 51	127 48	qdro	304 to 315 to 304	5	8	57.3	58.9	58.1	......	..	90	12.2	12.6	−0.4	179	12
11	39 54	129 14	bcqdm	304 to 292 to 315 to 338 to 11 to 292	2	6	55.5	57.5	56.5	......	..	92	13.8	14.5	−0.7	188	14
12	40 25	130 03	bcbodq	292 to 270 to 248 to 281 to 225	2	5	54.7	55.7	55.2	......	..	88	14.8	14.9	−0.1	160	11
13	43.04	131 01	bcbqrd	225 to 281 to 270 to 281	4	5	49.7	54.1	51.9	......	..	81	13.0	12.7	+0.3	175	19
14	46 28	130 51	qrdbc	292 to 304 to 270 to 225 to 214	5	7	40.9	49.7	45.3	−19.2	117	84	9.8	10.9	−1.1	125	27
15	48 42	132 52	qcbcodr	225 to 214 to 259 to 304 to 259	5	7	43.7	51.9	47.8	......	..	84	9.2	9.6	−0.4	172	21
16[15]	50 27	132 55	bcwodmf	236 to 292 to 45 to 0 to 315	1	5	46.8	55.3	51.0	+14.4	28	95	8.1	7.8	+0.3	122	18
17	53 44	131 51	mroqbd	338 to 292	6	9	40.5	....	....	−14.8	22	88	6.8	6.1	+0.7	115	29
					..	..	....	46.2	43.4	+ 5.7	16	..	....	....	.....	...	..
18[19]	56 35	133 05	cqdmh	315 to 349 to 304	7	10	37.1	47.7	42.4	− 9.1	10	86	4.8	4.4	+0.4	141	30
19[20]	56 48	135 36	qchbcb	338 to 292 to 349 to 292	6	10	47.7	59.7	53.7	......	..	87	4.6	4.2	+0.4	83	25
20	57 09	138 37	odb	292 to 338 to 349	3	5	61.1	62.1	61.6	+25.0	60	86	4.6	4.0	+0.6	238	12
21	56 53	143 00	cwofmd	349 to 326 to 0 to 45	3	5	51.8	59.3	55.6	......	..	95	2.6	3.5	−0.9	239	12
22[15]	56 47	144 47	ordfm	45 to 56 to 0 to 315 to 0 to 11 to 338	3	5	37.3	51.8	44.6	......	..	98	4.3	3.2	+1.1	263	17
23	56 39	147 07	mfdsr	0 to 338 to 259 to 236	1	6	35.4	38.5	37.0	−26.7	60	95	3.4	4.1	−0.7	159	5
24	54 24	151 00	ordpqc	225 to 214 to 225	4	6	37.8	49.9	43.8	......	..	90	4.4	5.7	−1.3	134	5
25	52 54	154 22	ocdbcm	225 to 259 to 315 to 0 to 34	2	4	47.7	50.9	49.3	+15.5	48	89	6.0	7.5	−1.5	190	11
26	52 37	156 35	odmr	34 to 0 to 315 to 304 to 191 to 248	1	5	42.2	47.7	45.0	− 8.7	33	95	7.6	8.0	−0.4	77	8
27	50 59	160 47	ocqb	270 to 248 to 326 to 292 to 270	5	7	43.3	55.1	49.2	......	..	84	8.8	9.5	−0.7	252	19
28	48 31	164 06	bcqdo	248 to 225 to 202 to 225 to 202 to 270	4	5	55.1	70.3	62.7	......	..	81	9.1	10.8	−1.7	250	6
29[21]	47 52	167 47	ocb	270 to 248 to 326 to 315 to 326	4	5	69.9	71.3	70.6	......	..	80	11.2	12.4	−1.2	302	14
30[22]	46 08	171 04	bcco	315 to 326 to 292 to 281 to 326	3	4	69.7	72.1	70.9	+29.9	99	86	13.0	12.0	+1.0	214	15
31	44 49	172 51	obcc	326 to 315 to 338 to 0 to 45 to 22	1	3	67.9	71.7	69.8	......	..	88	14.2	13.0	+1.2	113	8
Apr 1	Lyttelton		c	22 to 11	2	3	....	....	....	......	..	87	14.3	13.6	+0.7	...	..

[1]Extensive mirage of land appears in direction Banks Peninsula, 190 miles distant. [2]Antipodes Islands bear 210°, 25 miles distant. [3]Crossed 180th meridian of longitude. [4]Heavy south-east swell. [5]Passed first small iceberg. [6]Many large icebergs. Heavy snow squalls. High seas. [7]Icebergs. [8]Icebergs; high seas. [9]Many icebergs; water temperature dropped only 0.°2 as vessel approached berg. [10]Many icebergs; off northwest coast of South Georgia. [11]Entered Cumberland Bay, South Georgia. [12]Icebergs; passed through a stream of small bergs. [13]Icebergs; passed 3 miles north of Lindsay I. [14]Passed near Kerguelen I. [15]Aurora australis. [16]Passed one iceberg. [17]Aurora australis; much seaweed. [18]Sea surface covered with brilliant phosphorescent bodies. [19]Aurora australis; very brilliant both morning and evening. [20]Aurora australis; very brilliant. [21]Passed near Snares Islands. [22]Passing east of Stewart Island.

SOME DISCUSSIONS OF THE OCEAN MAGNETIC WORK.

ABSENCE OF MAGNETIC DEVIATIONS ON THE CARNEGIE.

As explained in Volume III, Researches of the Department of Terrestrial Magnetism, pages 435 to 437, every precaution possible was taken in the construction of the *Carnegie* and her equipment and with regard to the installations of the various instruments to insure that, at the various places where the magnetic observations were to be made, there would be no magnetic effects of the kind known as "ship deviations," of sufficient magnitude to be taken into account. Throughout the work of the *Carnegie* no effort has been spared to insure this result. All stores, tools, and magnetic instruments not in use have been stored aft. Heating stoves for use in cold weather were specially constructed of bronze and sheet copper and lined with special fire-brick. The spaces beneath the observation domes were kept free of magnetic material, and before each day's observations the locality near the domes and the bridge was closely inspected to insure the absence of any disturbing material. The quarters of officers and men were inspected frequently and every one on board was instructed to assist in keeping sheath-knives, marlinspikes, and any magnetic material away from the positions of the magnetic instruments. The cooks were allowed to keep only one day's supply of tinned food in the galleys, and their meat cleavers and large knives were stored aft except when special permission was given to use them in the galleys. In the installation of the electric-light equipment special care was used to provide nonmagnetic fittings, and the generator used in charging the storage batteries was not operated during magnetic observations. The forms on which the observations are recorded call for a statement by the observer that all magnetic material has been removed from his clothing and from the vicinity of the instrument he is using.

In addition to all these precautionary measures, which were a part of the daily program, the vessel was swung as opportunity offered, both in port and at sea, as heretofore, in order to control this matter *observationally*.

Thus in 1915, after the new atmospheric-electric observatory and equipment were installed, the *Carnegie* was swung in Gardiners Bay to control any disturbing effect which might have been introduced accidentally. Likewise in 1919, after the generator, storage batteries, and electric-light fixtures were installed, the vessel was swung in Chesapeake Bay. Swings were made at the beginning of a cruise, when the vessel was heavily loaded with supplies, and at the end of a cruise, when possible disturbing effects due to tinned food and other supplies were at a minimum.

The results of all these "swing observations," obtained during the period 1909 to 1921, have been grouped under two general headings: (1) swings in or near port and (2) swings at sea, far from land, where the local disturbance due to the nearness of magnetic material in the Earth is absent. The results for each heading of the ship are the means from the observations of both port-helm swing and starboard-helm swing, in general. Occasionally, however, a swing on only one helm could be made, while at other times the results are the mean of swings on four helms.

The vessel was swung by her own engine or with the aid of a tow-boat, using a tow-line of 600 feet or more in length, to insure that the machinery of the tow-boat would have no disturbing effect on the magnetic instruments. If no interruption occurred because of unfavorable conditions, the total time consumed for a complete swing of 8 headings, with both helms, averaged about 2 hours for declination and 4 to 5 hours for inclination and intensity.

For cruises I and II, 1909 to 1913, W. J. Peters was in command of the *Carnegie*, for cruises III, IV, and VI, 1914 to 1917, and 1919 to 1921, J. P. Ault was in command, and for Cruise V, 1917 to 1918, H. M. W. Edmonds was in command.

TABLE 27.—*Residuals from Magnetic Observations on the Carnegie during Swings of Vessel in Ports, 1909–1921.*

[The residuals are expressed in minutes of arc for declination and inclination, and in units of the fourth decimal C. G. S. for horizontal intensity. A plus sign means a deflection of the north-seeking end of the magnetic needle towards the east or downwards; it also signifies an increased value of the horizontal intensity.]

Station	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Means
Ship's head	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′
						Declination (*D*). Marine collimating-compass.										
N	−1	+1	−2	−3	.....	−7	+4	−4	−1	−1	+1	−2	+2	−2	+1	−1
NE	+1	+1	+1	0	.....	+7	−11	−2	0	+6	+2	+4	+4	+3	−1	+1
E	−5	+1	−5	+7	+6	+4	+8	+5	0	+2	+5	−2	−1	+7	−1	+2
SE	+1	−1	−2	−4	−7	−12	−8	−1	−2	−2	−4	−3	−4	+3	−3	−3
S	+3	+2	−1	−1	−2	0	−7	−3	+10	−7	−10	−2	+4	−5	+4	−1
SW	+4	+2	+5	+5	−2	+5	+13	+6	+7	+4	+3	+2	−2	+1	−1	+4
W	+2	−7	+4	−1	+1	+7	−6	−2	−4	−2	−1	+4	−2	0	+2	−1
NW	−5	−1	0	−2	+4	−3	+9	0	−8	0	+3	−1	−1	−7	+1	−1
Range	9	9	10	11	13	19	24	10	18	13	15	7	8	14	7	13\7
						Declination (*D*). Deflector.										
N	−2	−7	−3	+3	.....	−2	−5	−7	+10	+13	−7	+4	+2	+1	+2	0
NE	−8	0	−1	+6	.....	+3	.....	0	+4	+7	+1	−3	+5	+5	+11	+2
E	−3	+7	−13	+8	+17	−4	.....	−7	+2	−1	+9	−2	−4	+5	+3	+1
SE	+8	+21	−10	−4	−8	−10	.....	−7	−6	−1	+1	−8	−11	−9	−2	−3
S	0	−2	+8	−16	−8	−3	−4	+2	+4	−4	0	+1	−4	0	0	−2
SW	+8	−9	+11	+2	−6	+3	+17	+8	−5	−7	+3	+8	+8	+4	0	+3
W	+5	−8	+8	−1	+5	+7	+5	+8	−4	−7	+1	+4	+1	+3	−5	+1
NW	−6	−2	−1	+2	.....	+4	−13	0	−1	+1	−5	−4	+1	−8	−10	−2
Range	16	30	24	24	25	17	30	15	16	20	16	16	19	14	21	20\6
						Inclination (*I*). Sea dip-circle.										
N	−4	+8	−2	−2	+9	+1	−2	−1	0	+6	+4	−1	−2	+1	−2	+1
NE	+2	+2	0	+8	+9	0	+2	−1	+4	0	+1	+2	+3	+2	+2	+2
E	+1	−5	+4	+8	+6	0	+1	−1	+7	−8	−2	0	+1	+4	+4	+1
SE	0	−5	+2	−1	+2	+1	−1	−1	+2	−5	0	+1	−1	−1	−1	−1
S	−1	−14	0	−7	−5	−5	−3	0	−1	−2	+1	−1	−1	−2	+1	−2
SW	−3	−2	0	−1	−11	+2	−1	−1	−5	0	−2	−1	−1	−5	−1	−2
W	−1	−2	−2	−4	−13	+2	+2	+3	−5	+3	−4	+1	+1	+1	+2	−1
NW	+5	+19	−4	−1	+2	−2	+2	+2	−3	+7	+2	−1	0	0	−2	+2
Range	9	33	8	15	22	7	5	4	12	15	8	3	5	9	6	11\4
						Horizontal intensity (*H*). Deflector.										
Ship's head						Units of fourth decimal C. G. S.										
N	+3	.....	+1	+4	−2	+2	−1	−4	−2	−2	+9	+2	0	+3	0	+1
NE	−2	.....	−1	−4	0	−4	−1	+3	−3	+9	−2	+2	+2	+7	0	0
E	+2	.....	−8	−8	0	−2	−1	0	−2	−1	−8	−2	−2	−1	−1	−2
SE	−2	.....	−4	+10	−4	−1	+3	+1	+6	0	+6	0	−6	−7	0	0
S	+6	.....	+2	−8	+5	+3	+3	+2	+2	+8	+4	0	+2	+3	+2	+2
SW	+2	.....	+4	+5	+4	−2	+1	+3	+3	+1	−5	−1	+2	−3	0	+1
W	−4	.....	+1	−8	−2	−2	−3	−1	−2	−9	−8	−3	+1	+1	0	−3
NW	−4	.....	+6	+6	0	+6	−1	−4	−2	−5	+4	+2	+2	−3	+1	+1
Range	10	.....	14	18	9	10	6	7	9	18	17	5	8	14	3	11\5
						Horizontal intensity (*H*). Sea dip-circle.										
N	−2	.....	+1	+9	+3	+3	+1	0	+8	−8	+1	+3	+1	−1	+2	+1
NE	−1	.....	+1	+7	+1	−2	+1	+1	+1	−8	−2	+2	+1	−2	−2	0
E	0	.....	0	0	−2	−6	−2	−2	+1	−1	−5	−7	0	+1	+2	−2
SE	+2	.....	−1	+12	−6	+2	+1	0	+4	+6	+4	−6	−1	0	+4	+2
S	+1	.....	0	−11	−2	+6	+3	−2	0	+7	0	+1	−2	0	−2	0
SW	0	.....	0	−6	+3	+2	0	−3	−3	+10	−2	+2	−1	0	0	0
W	−2	.....	0	+7	+1	−6	−2	+2	−1	−8	−2	+1	0	+2	−4	−1
NW	−1	.....	−2	−15	+3	+4	−1	0	−3	+3	+3	+1	−1	+2	0	0
Range	4	.....	3	27	9	12	5	5	7	18	9	10	3	4	8	9\4

TABLE 27a.—*Description of Stations in Table 27.*

Station No.	Date	Place	Remarks
	1909		
1	Aug 31, Sept. 1, 2	Gardiners Bay, N. Y.	D. v. from Cheltenham data.
2	Oct. 18	Falmouth Bay, England	D. v. from Falmouth data. Residuals from deflector H rejected on account of small deflection angle. Roll 2° to 4°.
	1910		
3	June 22, 23, 25	Gardiners Bay, N. Y.	D. v. from Cheltenham.
4	Dec. 23, 24	Off Rio de Janeiro, Brazil	D. v. from Pilar data. Roll 7° to 15°.
	1913		
5	Oct. 4, 6	Falmouth Bay, England	No d. v. data available.
6	Dec. 15, 16	Gardiners Bay, N. Y.	D. v. from Cheltenham data.
	1914		
7	July 15, 18, 25	Soro Sund, Hammerfest, Norway.	D d. v. from simultaneous shore observations. H and I d. v. from Sodankyla data.
8	Oct. 15, 16, 18, 19, 20	Gardiners Bay, N. Y.	D. v. from Cheltenham data.
	1915		
9	Mar. 7, 8	Gardiners Bay, N. Y.	D. v. from Cheltenham data. Roll 7°.
10	June 29, July 3	Off Pearl Harbor, Honolulu	D. v. from Honolulu data. Roll 5° to 27°.
	1916		
11	May 10	Off New Brighton Beach, New Zealand.	D. v. from Christchurch 1910 and 1920 data for D and H. No. I d. v. data. Roll 1°.
12	Sept. 25	San Francisco Bay, Calif.	D. v. from Tucson, Sitka, and Honolulu data.
	1918		
13	June 9	Chesapeake Bay	D. v. from Cheltenham data.
	1919		
14	Oct. 11	Do	Do.
	1921		
15	Nov. 7	Do	D. v. from Cheltenham data of 1919 and 1920.

The residuals given in Tables 27 and 28 have been obtained by subtracting the mean value of the observed magnetic element for the 8 headings of the ship from the values for the individual headings. The plus sign is given the declination (D) when east and the inclination (I) when the north-seeking end of the dip needle is below the horizon; the horizontal intensity is always positive. Diurnal-variation corrections were applied to the observations on the various headings, obtained during the swings in port, in order to refer all values to the same time. These corrections were obtained from the data of nearby observatories, as indicated in the remarks. Results of swings at sea have not been corrected for diurnal variation.

An inspection of the figures in Tables 27 and 28 shows that the residuals are small; for D and I they generally are less than 0°.1, and for H, usually less than 0.0005 C. G. S. The residuals are, in fact, on the order of the error of observation.

In Table 27 the results have been tabulated according to the different positions of the instruments. The declination results with marine collimating-compass No. 1 were obtained on the bridge; the declination and horizontal-intensity results with deflector were obtained in the after observation dome; and the horizontal intensity and inclination results with sea dip-circle were obtained in the forward dome.

This method of tabulation and the use of more exact diurnal-variation corrections will explain the differences in the Gardiners Bay residuals as published in Table 101, Volume III, Researches of the Department of Terrestrial Magnetism, and those published herewith in Table 27.

An inspection of Tables 27 and 28 shows that the results obtained from the sea swings are practically of the same order as those obtained from the port swings. The declination residuals, in general, are larger and more irregular for the deflector than for the marine collimating compass, a result to be expected in view of the difference in the two methods of observation.

TABLE 28.—*Residuals from Magnetic Observations on the Carnegie during Swings of Vessel at Sea, 1909–1921.*

[The residuals are expressed in minutes of arc for declination and inclination, and in units of the fourth decimal C. G. S. for horizontal intensity. A plus sign means a deflection of the north-seeking end of the magnetic needle towards the east or downwards; it also signifies an increased value of the horizontal intensity.]

I. DECLINATION SWINGS

Declination (*D*)

Station	Marine collimating-compass 1	2	3	4	5	Means	Deflector 1	2	3	4	5	Means
Ship's head	′	′	′	′	′	′	′	′	′	′	′	′
N	+2	...	−1	...	0	0	−8	...	+2	...	+1	−2
NE	+4	...	−4	...	+3	+1	+5	...	−8	...	+2	0
E	...	...	+4	+3	+2	+3	...	...	−5	+4	+1	0
SE	...	+8	+2	−5	−1	+1	...	+4	−5	−14	+1	−4
S	−1	+2	−1	−3	−2	−2	+7	+6	+2	+8	+5	+6
SW	+2	+4	−2	−1	0	+1	−5	+4	−6	+2	+2	−1
W	−3	−7	0	+5	0	−1	+6	−2	+8	...	−6	+2
NW	−2	−7	+1	...	−1	−2	−5	−11	+12	...	−5	−2
Range	7	15	8	10	5	9\5	15	17	20	22	11	17\10

Station No.	Date	Position: Lat.	Long. East of Gr.	Roll
	1913	° ′	° ′	°
1	Apr 17	12 44 S	334 05	14
	1915			
2	Apr 15	4 18 N	279 35	2
3	Aug 15	56 37 N	176 59	10
	1916			
4	Aug 27	47 15 N	167 13	12
	1921			
5	May 31	4 26 N	215 17	5 to 15

II. HORIZONTAL-INTENSITY AND INCLINATION SWINGS

Horizontal intensity (*H*)

Station	Deflector 2	4	5	6	7	8	9	10	11	12	Means	Sea dip-circle 1	2	3	4	8	9	10	11	12	Means
Ship's head	Units of fourth decimal C. G. S.											Units of fourth decimal C. G. S.									
N	0	+2	+1	+ 1	...	−3	...	−3	...	+ 1	0	0	+5	−5	+1	−1	...	−3	...	+8	0
NE	+ 4	−6	+1	−13	...	−3	...	−3	...	+ 2	−3	...	+9	+3	+3	−1	...	−5	...	+3	+2
E	+12	+3	−1	− 9	−3	−2	+2	−2	+11	− 4	+1	−1	−3	+4	−4	−3	−3	−2	0	+3	−1
SE	+18	...	...	...	−5	+3	−3	−2	0	+10	+3	+1	−1	−5	...	+1	−2	−3	−3	0	−2
S	− 4	+4	...	...	−1	+1	+9	+6	− 4	− 6	+1	−7	+1	−6	+1	+2	+5	+6	+2	+4	+1
SW	...	−6	+1	+ 6	+4	−2	−6	+4	− 6	− 6	−1	0	...	...	−3	−1	+3	+2	+3	−4	0
W	−14	0	−1	+ 2	+3	+4	−5	−3	− 7	+ 2	−2	+6	−8	+3	+1	+1	−1	+2	+2	−8	0
NW	−19	+1	−1	+13	+4	+2	+3	+2	+ 5	+ 1	+1	0	0	+5	+1	+1	0	+1	−2	−4	0
Range	37	10	2	26	9	7	15	9	18	16	15\6	13	17	11	7	5	8	11	6	12	10\4

Inclination (*I*)

Station	4	5	6	7	8	9	10	11	12	Means
Ship's head	′	′	′	′	′	′	′	′	′	′
N	+3	+1	+ 3	...	−4	...	−2	...	−4	−1
NE	+2	+2	+11	...	+2	...	−2	...	−6	+1
E	+8	−5	+13	+2	+2	−5	+2	−1	+2	+2
SE	...	...	....	+3	+1	−4	0	+5	+4	+1
S	−1	...	....	−1	0	+3	−1	+3	+1	+1
SW	−6	−2	−11	0	+2	+1	+4	+2	−1	−1
W	−5	+4	− 8	−4	−1	+6	−1	+1	−2	−1
NW	−1	0	− 8	−2	−1	−3	+2	−8	+5	−2
Range	14	9	24	7	6	11	6	13	11	11\4

Station No.	Date	Position: Lat.	Long. East of Gr.	Roll
	1911	° ′	° ′	°
1	May 14	39 29 S	73 53	11
2	May 20	33 50 S	77 46	16
3	Jun 1	5 07 S	75 45	12
	1912			
4	Aug 15	0 58 N	247 24	10
	1913			
5	Mar 21	35 35 S	7 23	10
6	Aug 15	31 59 N	320 02	..
7	Aug 18	33 28 N	320 00	4
	1914			
8	Aug 7	77 11 N	4 58	4
	1915			
9	Apr 15	4 08 N	279 35	2
10	Aug 15	56 28 N	177 02	10
	1916			
11	Mar 16	50 23 S	132 54	12
12	Aug 26	47 05 N	165 22	9

The same general conclusions as given in Volume III, Researches of the Department of Terrestrial Magnetism, page 437, can be made from a study of all the swings of the *Carnegie* both in port and at sea. The residuals are mainly due to observational error, and if there are any outstanding effects to be ascribed to any magnetic material on the vessel, they are of such a subordinate magnitude as not to require being taken into account in the observational or in the computational work. Thus it can be stated, without any doubt or reservation, that the nonmagnetic feature of the *Carnegie's* construction and operation has been maintained in a practical way throughout all her work and cruises.

MAGNETIC-CHART DIFFERENCES AS SHOWN BY THE CARNEGIE RESULTS, 1915–1921.

In the earlier cruises of the *Galilee* and *Carnegie* there were disclosed in the mariner's charts giving the compass direction (magnetic declination), chart differences amounting to 3°, 5°, 10°, and even as much as 16° in certain parts of the oceans, the differences at times continuing in the same direction for several thousand miles. Equally serious differences were found in the magnetic charts showing inclination or dip of the magnetic needle and strength of the Earth's magnetic field; the differences in dip not infrequently amounted to over 9° and the chart values of the Earth's magnetic intensity were found to differ at times by amounts reaching and even exceeding 10 per cent. However, the improvement in the magnetic charts due to the data supplied promptly from time to time to the leading hydrographic establishments by the Carnegie Institution and by other organizations is shown by the fact that, during Cruise VI of the *Carnegie*, for the 1920 United States magnetic charts, the chart differences in declination were usually less than 1° and reached 2°.5 only once, in the Indian Ocean; the chart differences in dip exceeded 3° only once; and the chart differences in horizontal intensity rarely exceeded 4 per cent.

Table 29 will show the magnitude of the chart differences as determined from a comparison of the *Carnegie* observed values of the magnetic elements with values scaled from the most recent British and United States magnetic charts. Secular variation corrections were applied to the magnetic declinations scaled from the charts to reduce the values to the epoch of the *Carnegie* observations.

If we compare the mean ranges and the means for cruises IV and V, omitting the sub-Antarctic portion of Cruise IV, with those for Cruise VI, we see that they differ very little in declination, due mainly to the large chart differences obtained on Cruise VI in the South Atlantic and Indian oceans, regions not covered during cruises IV and V; for inclination and horizontal intensity a marked improvement is shown in the magnetic charts. For the North Atlantic Ocean, the values of the magnetic declination observed on Cruise IV in 1915 en route from New York to Cristobal gave a mean chart difference of 0°.8 W, compared with United States Hydrographic Office chart for 1910; on Cruise V, 1918, the values of the magnetic declination observed en route from Cristobal to Newport News gave a mean chart difference of 0°.4 E, compared with United States Hydrographic Office chart for 1915; on Cruise VI, 1921, the values of the magnetic declination observed en route from Cristobal to Newport News gave a mean chart difference of 0°.0, compared with United States Hydrographic Office chart for 1920; thus showing a steady improvement in the magnetic charts covering this region. The mean ranges for these three periods were 2°.4, 1°.7, and 1°.4, respectively, which again serves to point out the steady improvement in the charts.

It is significant that the regions of greatest variation in the annual change, the South Atlantic and the Indian oceans, show the largest chart differences, thus emphasizing the need for further control in these regions. Only two cruises have been made in the South Atlantic and Indian oceans, Cruise II in 1911, and Cruise VI in 1920. Cruise

TABLE 29.—*Chart Differences, Cruises IV, V, and VI, 1915–1921.*

Cruise IV	Date 1915–1917			Declination						Inclination				Horizontal intensity[1]			
			No. stations	British (1912)			U. S. (1910)			No. stations	British (1907)			No. stations	U. S. (1900)		
				Range		Mean	Range		Mean		Range		Mean		Range		Mean
				° °	°	°	° °	°	°		° °	°	°				
New York–Cristobal	Mar	9–Mar	24	26	1.2 W to 0.6 E	1.8	0.1 W	2.2 W to 0.2 E	2.4	0.8 W	17	3.0 N to 0.7 N	2.3	2.0 N	17	− 7 to −23	16	−17
Cristobal–Honolulu	Apr	12–May	21	71	0.7 W to 1.4 E	2.1	0.5 E	0.2 W to 1.7 E	1.9	0.8 E	39	4.4 N to 1.1 S	5.5	0.5 N	39	+ 7 to −22	29	−11
Honolulu–Dutch Harbor	Jul	4–Jul	23	31	0.4 W to 1.2 E	1.6	0.4 E	0.3 W to 1.0 E	1.3	0.2 E	17	1.6 N to 0.9 S	2.5	0.7 N	17	− 2 to −20	18	− 9
								U. S. (1915)										
Dutch Harbor–Lyttelton	Aug	5–Nov	3	157	1.8 W to 0.7 E	2.5	0.5 W	1.6 W to 1.0 E	2.6	0.4 W	87	0.8 N to 4.6 S	5.4	1.9 S	87	+ 5 to −18	23	− 5
Lyttelton–South Georgia	Dec	6–Jan	12	74	1.8 W to 3.8 E	5.6	0.3 E	2.2 W to 2.0 E	4.2	0.3 W	37	1.8 N to 1.2 S	3.0	0.1 N	37	+ 6 to −11	17	− 3
South Georgia–Lyttelton	Jan	15–Apr	1	155	12.0 W to 6.1 E	18.1	1.2 W	12.5 W to 4.8 E	17.3	1.1 W	77	1.9 N to 2.7 S	4.6	0.5 S	77	+24 to −13	37	− 1
Lyttelton–Pago Pago	May	17–Jun	7	34	0.8 W to 1.2 E	2.0	0.0	0.9 W to 1.0 E	1.9	0.1 W	22	0.2 S to 4.6 S	4.4	2.1 S	22	+ 4 to − 3	7	+ 1
Pago Pago–Guam	Jun	19–Jul	17	53	1.1 W to 0.1 E	1.2	0.5 W	0.8 W to 0.4 E	1.2	0.3 W	26	0.9 S to 5.7 S	4.8	3.1 S	26	− 5 to −24	19	−14
Guam–San Francisco	Aug	8–Sep	21	61	1.3 W to 1.0 E	2.3	0.2 W	1.4 W to 0.5 E	1.9	0.2 W	45	0.9 N to 3.6 S	4.5	0.4 S	45	+ 2 to −11	13	− 2
San Francisco–Easter I.	Nov	2–Dec	24	97	0.7 W to 1.4 E	2.1	0.0	1.0 W to 0.8 E	1.8	0.2 W	52	1.0 N to 7.9 S	8.9	2.8 S	52	+11 to −20	31	− 3
Easter I.–Buenos Aires	Jan	2–Mar	2	105	1.0 W to 2.3 E	3.3	0.3 E	0.8 W to 1.1 E	1.9	0.0	59	1.7 N to 7.4 S	9.1	3.1 S	9	+18 to −12	30	0

Cruise V	Date 1917–1918			Declination						Inclination				Horizontal intensity[1]			
			No. stations	British (1917)			U. S. (1915)			No. stations	British (1907)			No. stations	U. S. (1900)		
				Range		Mean	Range		Mean		Range		Mean		Range		Mean
				° °	°	°	° °	°	°		° °	°	°				
Buenos Aires–Talcahuano	Dec	6–Jan	10	63	0.6 W to 0.8 E	1.4	0.1 E	0.6 W to 0.8 E	1.4	0.0	35	1.7 N to 1.3 S	3.0	0.6 N	35	− 7 to −14	7	−10
Talcahuano–Callao	Jan	23–Feb	22	62	0.4 W to 0.8 E	1.2	0.3 E	0.9 W to 0.2 E	1.1	0.2 W	31	1.9 N to 5.0 S	6.9	1.7 S	31	− 2 to −13	11	− 8
Callao–Balboa	Mar	29–Apr	24	52	0.4 W to 0.6 E	1.0	0.2 E	0.2 W to 0.7 E	0.9	0.2 E	26	4.4 N to 5.9 S	10.3	0.4 N	26	− 6 to −17	11	−11
Cristobal–Newport News	May	12–Jun	4	44	0.7 W to 0.8 E	1.5	0.3 E	0.7 W to 1.0 E	1.7	0.4 E	23	3.6 N to 1.0 N	2.6	1.9 N	23	−15 to −27	12	−22
Means, cruises IV and V, omitting Lyttelton to South Georgia to Lyttelton						1.8	0.1 E	....	1.7	0.0	...	....	5.4	0.7 S	...	....	17	− 9

Cruise VI	Date 1919–1921			Declination						Inclination				Horizontal intensity[1]			
			No. stations	British (1917)			U. S. (1920)			No. stations	U. S. (1920)			No. stations	U. S. (1920)		
				Range		Mean	Range		Mean		Range		Mean		Range		Mean
				° °	°	°	° °	°	°		° °	°	°				
Washington–Dakar	Oct	14–Nov	22	50	0.7 W to 0.6 E	1.3	0.2 W	0.9 W to 0.5 E	1.4	0.2 W	30	0.8 N to 1.2 S	2.0	0.1 S	30	+ 4 to − 1	5	+ 2
Dakar–Buenos Aires	Nov	27–Jan	18	89	0.9 W to 1.4 E	2.3	0.2 E	1.1 W to 1.4 E	2.5	0.1 E	46	0.3 S to 3.3 S	3.0	1.7 S	46	+ 4 to − 4	8	0
Buenos Aires–St. Helena	Feb	24–Mar	26	63	1.8 W to 1.0 E	2.8	0.4 W	2.0 W to 0.8 E	2.8	0.4 W	31	0.0 to 2.1 S	2.1	1.2 S	31	+ 3 to − 7	10	− 3
St. Helena–Cape Town	Apr	4–Apr	23	40	1.6 W to 0.0	1.6	0.9 W	1.4 W to 0.5 E	1.9	0.6 W	19	0.5 S to 1.5 S	1.0	1.0 S	19	+ 1 to − 7	8	− 3
Cape Town–Colombo	May	21–Jun	29	80	1.8 W to 2.3 E	4.1	0.3 W	1.9 W to 2.5 E	4.4	0.3 W	39	3.3 N to 1.8 S	5.1	0.7 N	39	+ 6 to − 8	14	+ 1
Colombo–Fremantle	Jul	24–Aug	30	68	1.8 W to 0.5 E	2.3	0.1 W	1.9 W to 0.3 E	2.2	0.4 W	35	0.2 N to 1.6 S	1.8	0.6 S	35	+ 5 to − 6	11	+ 2
Fremantle–Lyttelton	Oct	1–Oct	20	35	0.5 W to 1.3 E	1.8	0.3 E	0.7 W to 1.2 E	1.9	0.3 E	18	0.4 N to 0.8 S	1.2	0.0	18	+ 4 to − 5	9	− 1
Lyttelton–Papeete	Nov	19–Dec	22	54	0.5 W to 1.2 E	1.7	0.1 E	0.7 W to 1.2 E	1.9	0.1 E	33	1.0 N to 1.1 S	2.1	0.0	33	+ 8 to − 9	17	+ 3
Papeete–San Francisco	Jan	4–Feb	19	81	0.7 W to 1.1 E	1.8	0.0	0.5 W to 0.9 E	1.4	0.1 E	44	0.6 N to 1.6 S	2.2	0.3 S	44	+ 3 to − 6	9	0
San Francisco–Honolulu	Mar	29–Apr	11	27	0.8 W to 0.1 E	0.9	0.4 W	0.7 W to 0.2 E	0.9	0.1 W	14	0.1 N to 1.1 S	1.2	0.6 S	14	0 to − 3	3	− 1
Honolulu–Apia	Apr	29–Jun	20	96	1.0 W to 1.1 E	2.1	0.1 W	0.7 W to 1.0 E	1.7	0.0	48	0.3 N to 1.5 S	1.8	0.5 S	48	0 to − 6	6	− 2
Apia–Rarotonga	Jul	26–Aug	11	28	0.2 W to 0.6 E	0.8	0.3 E	0.5 W to 0.4 E	0.9	0.1 E	17	0.1 N to 0.7 S	0.8	0.3 S	17	+ 6 to + 1	5	+ 4
Rarotonga–Balboa	Aug	12–Oct	6	86	0.5 W to 0.9 E	1.4	0.2 E	0.5 W to 0.7 E	1.2	0.2 E	51	1.8 N to 0.5 S	2.3	0.4 N	51	+ 9 to − 2	11	+ 3
Cristobal–Newport News	Oct	21–Nov	6	32	0.6 W to 1.2 E	1.8	0.1 E	0.6 W to 0.8 E	1.4	0.0	13	1.8 N to 0.1 N	1.7	0.7 N	13	+ 7 to − 2	9	+ 3
Means, Cruise VI						1.9	0.1 W	....	1.9	0.1 W	...	....	2.0	0.3 S	...	....	9	+ 1

[1] Units of third decimal C. G. S.

IV was planned to cover a portion of the South Atlantic, but the plans were changed on account of the war.

The magnitude of the chart differences can be ascribed, for the most part, to the uncertain knowledge of the annual change in these regions. Thus special effort should be made in future cruises of the *Carnegie* to cover the Atlantic and Indian oceans, in an effort to control the annual changes in the magnetic elements.

PRELIMINARY VALUES OF THE ANNUAL CHANGES OF THE MAGNETIC ELEMENTS AS DETERMINED FROM THE GALILEE AND CARNEGIE RESULTS, 1905–1921.

The following tables contain the average annual change values of the magnetic elements as deduced from the final results of the observations on the *Galilee* and *Carnegie* in the vicinity of the intersections of their various tracks. As it is practically impossible to repeat observations at precisely the same spot, and since, to eliminate the observational error, it is desirable to utilize as large a number of observations as is practicable, some scheme for reducing a number of observations to one central geographic position must be devised. This has been accomplished in a graphical and preliminary way as follows:

All values utilized have been compared with values as shown on the United States Hydrographic Office magnetic charts for 1920. The difference in the chart corrections thus obtained for two groups of values, divided by the time-interval in years, was taken as the average annual change for the mean position of the two groups under consideration. This serves in a graphical way to avoid the errors introduced in a region where the change in the magnetic elements with their change in geographic position may not be considered linear.

The results thus obtained are sufficiently accurate for all practical purposes in view of the large number of values utilized in the formation of groups for the various track intersections. A mathematical discussion and least-square reduction of all secular-variation data obtained by the Department both on land and at sea will be published in a future volume of the Department's researches.

For a more detailed discussion of the difficulties encountered in determining the annual changes of the magnetic elements at sea, reference can be made to Volume III, Researches of the Department of Terrestrial Magnetism, pages 430–433. The present tables are based on different groupings than those found on pages 432 and 433 of Volume III, and more values have been utilized in each group.

The number of observational results from which the annual change is deduced is given for each date and also the least number that occurs in any group. These numbers, together with the time-interval, are some indication of the relative reliability of the corresponding annual change. The observations were not corrected for diurnal variation of the magnetic elements, since this variation is usually eliminated in the methods of observation.

The annual changes for the declination and inclination are referred invariably to the north-seeking end of the magnetic needle. Thus 6′ E means that the north-seeking end of the compass moved to the east at the average annual rate of 6′ during the period shown in the third column of the tables; 3′ S means that the north-seeking end of the dip needle moved upwards at the average annual rate of 3′ during the period in the third column. The progressive annual change, or variation in the annual change with time, is given for many of the intersections where the *Galilee* or *Carnegie* passed over the region more than twice. The intersections have been arranged in accordance with decreasing northerly latitude for the three large oceans.

TABLE 30.—*Average Annual Changes for the Atlantic Ocean.*

Latitude	Longitude East of Gr.	Approximate dates	Time-interval	Average annual change			Number of values utilized	
				Declination	Inclination	Horizontal intensity	First date	Second date
°	°		years	′	′	c. g. s.		
49.4 N	333.7	1909.8–1913.7	3.9	6 E	...	...	5	7
		1909.8–1914.5	4.7	4 E	...	...	5	8
48.9 N	333.0	1909.8–1913.7	3.9	...	3 S	0.0000	4	8
		1909.8–1914.5	4.7	...	1 S	+ .0001	4	5
47.0 N	309.1	1909.8–1914.8	5.0	7 E	...	...	8	17
47.1 N	308.5	1909.7–1914.7	5.0	...	3 S	.0000	6	10
44.5 N	345.8	1909.8–1913.7	3.9	6 E	...	...	20	22
44.8 N	346.0	1909.8–1913.7	3.9	...	6 S	+ .0002	13	19
		1909.8–1914.6	4.8	5 W	...	...	8	17
40.6 N	298.0	1914.6–1919.8	5.2	8 W	...	...	17	6
		1909.8–1919.8	10.0	7 W	...	...	8	6
		1910.1–1914.6	4.5	...	1 S	− .0004	6	9
40.0 N	298.5	1914.6–1919.8	5.2	...	0	− .0003	9	4
		1910.1–1919.8	9.7	...	0	− .0004	6	4
39.7 N	290.8	1909.9–1913.9	4.0	4 W	...	...	13	6
		1909.9–1914.7	4.8	6 W	...	...	13	11
		1910.0–1914.3	4.3	...	2 N	− .0007	12	15
		1915.2–1919.8	4.6	...	4 S	− .0004	2	2
38.8 N	289.9	1910.0–1915.2	5.2	...	6 N	− .0009	12	2
		1910.0–1919.8	9.8	...	2 N	− .0006	12	2
		1914.3–1919.8	5.5	...	1 N	− .0007	15	2
		1910.5–1913.9	3.4	2 W	...	...	6	6
		1914.4–1919.8	5.4	4 W	...	...	5	7
38.1 N	310.3	1910.5–1914.4	3.9	4 W	...	...	6	5
		1910.5–1919.8	9.3	4 W	...	...	6	7
		1913.9–1919.8	5.9	4 W	...	...	6	7
		1910.5–1914.2	3.7	...	6 S	+ .0004	4	6
38.3 N	309.4	1914.2–1919.8	5.6	...	1 N	− .0001	6	5
		1910.5–1919.8	9.3	...	2 S	+ .0001	4	5
37.8 N	322.2	1913.6–1919.8	6.2	1 W	...	...	14	13
37.4 N	322.3	1913.6–1919.8	6.2	...	4 S	.0000	9	9
37.3 N	334.7	1913.8–1919.8	6.0	2 E	...	...	8	11
37.2 N	333.9	1913.8–1919.8	6.0	...	5 S	+ .0005	12	7
		1915.2–1918.4	3.2	5 W	...	...	5	15
33.6 N	285.9	1918.4–1921.8	3.4	4 W	...	...	15	9
		1915.2–1921.8	6.6	4 W	...	...	5	9
		1915.2–1918.4	3.2	...	3 S	− .0004	3	7
33.8 N	286.0	1918.4–1920.8	2.4	...	4 N	− .0007	7	6
		1915.2–1920.8	5.6	...	0	− .0005	3	6
29.1 N	340.2	1909.9–1919.9	10.0	4 E	...	...	11	12
28.8 N	340.0	1909.9–1919.9	10.0	...	8 S	+ .0005	6	7
		1910.0–1915.2	5.2	12 W	...	...	6	9
		1910.6–1915.2	4.6	15 W	...	...	13	9
24.5 N	291.7	1910.6–1921.8	11.2	7 W	...	...	13	12
		1915.2–1921.8	6.6	2 W	...	...	9	12
		1910.0–1921.8	11.8	6 W	...	...	6	12
		1910.4–1915.2	4.8	...	6 N	− .0008	9	6
24.0 N	290.6	1915.2–1921.8	6.6	...	4 N	− .0011	6	5
		1910.4–1921.8	11.4	...	5 N	− .0010	9	5
20.6 N	325.6	1909.9–1913.6	3.7	4 W	...	...	17	11
20.6 N	325.6	1909.9–1913.6	3.7	...	9 S	+ .0001	9	6
		1915.2–1918.4	3.2	2 W	...	...	9	15
15.2 N	282.9	1918.4–1921.8	3.4	2 E	...	...	15	10
		1915.2–1921.8	6.6	0	...	...	9	10
		1915.2–1918.4	3.2	...	4 N	− .0019	7	8
14.6 N	282.2	1918.4–1921.8	3.4	...	11 N	+ .0004	8	4
		1915.2–1921.8	6.6	...	8 N	− .0007	7	4
9.6 S	347.5	1913.6–1920.0	6.4	2 W	...	...	8	11
9.7 S	347.7	1913.6–1920.0	6.4	...	18 S	− .0003	6	6
14.2 S	344.0	1913.3–1920.0	6.7	4 W	...	...	11	12
14.3 S	343.8	1913.3–1920.0	6.7	...	16 S	− .0004	6	6
15.6 S	324.2	1910.9–1913.4	2.5	8 W	...	...	10	22
15.2 S	324.5	1910.9–1913.4	2.5	...	13 S	− .0006	9	18

TABLE 30.—*Average Annual Changes for the Atlantic Ocean*—Concluded.

Latitude	Longitude East of Gr.	Approximate dates	Time-interval	Average annual change			Number of values utilized	
				Declination	Inclination	Horizontal intensity	First date	Second date
°	°		*years*	′	′	*c. g. s.*		
17.0 S	353.6	1913.3–1920.2	6.9	1 W	...	...	18	14
17.1 S	353.9	1913.3–1920.2	6.9	...	15 S	−0.0009	11	6
25.4 S	329.8	1913.4–1920.0	6.6	8 W	...	...	8	15
26.0 S	330.4	1913.4–1920.0	6.6	...	12 S	− .0004	6	9
26.4 S	5.7	1913.2–1920.2	7.0	4 E	...	...	9	13
24.8 S	5.8	1913.2–1920.2	7.0	...	13 S	− .0006	7	6
31.4 S	344.4	1913.5–1920.3	6.8	8 W	...	...	9	16
31.4 S	345.1	1913.4–1920.3	6.9	...	12 S	− .0007	9	7
35.7 S	16.1	1911.2–1920.3	9.1	11 E	...	...	3	7
36.3 S	15.5	1911.2–1920.3	9.1	...	9 S	− .0014	2	4
36.8 S	353.1	1911.2–1913.4	2.2	4 E	...	...	5	6
		1912.3–1920.2	7.9	5 W	...	...	11	20
		1911.2–1920.2	9.0	4 W	...	...	5	20
		1913.4–1920.2	6.8	6 W	...	...	6	20
36.8 S	352.2	1911.2–1913.4	2.2	...	17 S	− .0008	4	5
		1913.4–1920.2	6.8	...	11 S	− .0009	5	10
		1911.2–1920.2	9.0	...	13 S	− .0009	4	10
37.1 S	306.5	1911.1–1917.1	6.0	10 W	...	...	19	9
		1917.1–1917.9	0.8	11 W	...	...	9	19
		1917.9–1920.1	2.2	10 W	...	...	19	21
		1911.1–1917.9	6.8	10 W	...	...	19	19
		1911.1–1920.1	9.0	10 W	...	...	19	21
		1917.1–1920.1	3.0	10 W	...	...	9	21
37.5 S	306.5	1911.1–1917.2	6.1	...	4 N	− .0003	16	5
		1917.1–1917.9	0.8	...	8 S	− .0008	5	8
		1917.9–1920.1	2.2	...	24 S	− .0010	8	6
		1911.1–1917.9	6.8	...	2 N	− .0004	16	8
		1911.1–1920.1	9.0	...	4 S	− .0005	16	6
		1917.1–1920.1	3.0	...	19 S	− .0009	5	6
37.8 S	6.7	1911.2–1913.2	2.0	10 E	...	...	8	6
		1913.2–1920.3	7.1	0	...	...	6	6
		1911.2–1920.3	9.1	2 E	...	...	8	6
37.1 S	6.4	1911.2–1913.2	2.0	...	27 S	− .0012	5	8
		1913.2–1920.3	7.1	...	13 S	− .0013	8	4
		1911.2–1920.3	9.1	...	16 S	− .0013	5	4
41.3 S	348.0	1911.2–1920.2	9.0	7 W	...	...	5	9
41.5 S	345.2	1911.2–1920.2	9.0	...	9 S	− .0010	7	6
48.7 S	298.8	1917.1–1917.9	0.8	5 W	...	...	10	20
48.3 S	299.1	1917.1–1918.0	0.9	...	3 N	+ .0003	7	10
53.1 S	324.2	1913.1–1916.0	2.9	11 W	...	...	2	12
53.3 S	324.4	1913.1–1916.0	2.9	...	7 N	− .0004	7	7

TABLE 31.—*Average Annual Changes for the Indian Ocean.*

Latitude	Longitude East of Gr.	Approximate dates	Time-interval	Declination	Inclination	Horizontal intensity	First date	Second date
°	°		*years*	′	′	*c. g. s.*		
10.9 N	63.9	1911.7–1920.5	8.8	2 W	...	...	18	17
10.6 N	64.6	1911.7–1920.5	8.8	...	8 N	+0.0004	10	7
5.3 N	80.3	1911.6–1920.5	8.9	4 E	...	...	26	11
5.2 N	80.5	1911.7–1920.5	8.8	...	2 N	+ .0004	6	6
		1911.5–1920.5	9.0	...	1 N	+ .0006	12	6
24.4 S	63.2	1911.6–1920.4	8.8	13 W	...	...	14	14
23.8 S	63.0	1911.6–1920.4	8.8	...	6 N	+ .0004	10	7
31.0 S	77.9	1911.4–1920.6	9.2	18 W	...	...	6	18
30.8 S	77.5	1911.4–1920.6	9.2	...	1 S	− .0003	7	9
35.0 S	95.0	1911.9–1916.1	4.2	7 W	...	...	15	19
		1916.1–1920.6	4.5	14 W	...	...	19	10
		1911.9–1920.6	8.7	10 W	...	...	15	10
35.5 S	95.7	1911.9–1916.1	4.2	...	1 S	− .0010	8	9
		1916.1–1920.6	4.5	...	2 S	− .0005	9	5
		1911.9–1920.6	8.7	...	2 S	− .0007	8	5
38.9 S	31.3	1911.3–1920.4	9.1	8 E	...	...	3	8
38.7 S	31.4	1911.3–1920.4	9.1	...	2 S	− .0009	6	6
45 0 S	128.4	1916.2–1920.8	4.6	8 W	...	...	25	13
45.3 S	128.4	1916.2–1920.8	4.6	...	2 N	− .0001	12	7

TABLE 32.—*Average Annual Changes for the Pacific Ocean.*

Latitude	Longitude East of Gr.	Approximate dates	Time-interval	Average annual change			Number of values utilized	
				Declination	Inclination	Horizontal intensity	First date	Second date
°	°		*years*	′	′	*c. g. s.*		
52.4 N	216.2	1907.6–1916.7	9.1	7 E	...	...	3	6
51.1 N	212.7	1907.6–1916.7	9.1	...	2 S	0.0000	3	5
49.8 N	189.2	1915.5–1916.6	1.1	6 W	...	...	9	7
		1906.7–1915.6	8.9	6 W	...	...	7	14
45.4 N	167.0	1915.6–1916.6	1.0	12 W	...	...	14	15
		1906.7–1916.6	9.9	6 W	...	...	7	15
		1906.7–1915.6	8.9	...	4 S	.0000	7	9
46.1 N	166.9	1915.6–1916.6	1.0	...	9 S	+ .0001	9	9
		1906.7–1916.6	9.9	...	1 S	.0000	7	9
42.9 N	190.2	1907.0–1915.5	8.5	1 W	...	...	9	12
43.5 N	191.1	1906.7–1915.5	8.8	...	2 S	− .0003	4	7
		1907.5–1915.5	8.0	...	4 S	+ .0002	5	7
		1907.6–1916.7	9.1	1 E	...	...	6	17
40.8 N	222.6	1916.7–1921.1	4.4	3 E	...	...	17	15
		1907.6–1921.1	13.5	2 E	...	...	6	15
		1907.6–1916.7	9.1	...	1 S	.0000	6	12
40.7 N	222.9	1916.7–1921.1	4.4	...	6 S	− .0004	12	10
		1907.6–1921.1	13.5	...	3 S	− .0002	6	10
37.7 N	194.1	1915.5–1921.1	5.6	1 W	...	...	9	14
37.7 N	194.4	1915.5–1921.1	5.6	...	1 S	− .0003	6	7
		1906.6–1916.8	10.2	5 E	...	...	17	15
35.0 N	233.2	1916.8–1921.2	4.4	1 W	...	...	15	22
		1906.6–1921.2	14.6	3 E	...	...	17	22
		1905.7–1906.7	1.0	...	7 S	− .0003	12	6
		1906.7–1908.4	1.7	...	9 S	− .0003	6	4
		1908.4–1916.8	8.4	...	2 N	− .0003	4	10
		1916.8–1921.2	4.4	...	4 S	− .0002	10	12
34.5 N	232.9	1905.7–1908.4	2.7	...	9 S	− .0003	12	4
		1905.7–1916.8	11.1	...	1 S	− .0003	12	10
		1905.7–1921.2	15.5	...	2 S	− .0003	12	12
		1906.7–1916.8	10.1	...	0	− .0003	6	10
		1906.7–1921.2	14.5	...	1 S	− .0003	6	12
		1908.4–1921.2	12.8	...	0	− .0003	4	12
32.5 N	216.6	1907.6–1921.4	13.7	1 E	...	...	6	13
32.1 N	217.1	1907.6–1921.4	13.7	...	1 S	− .0002	6	8
		1906.6–1912.3	5.7	2 W	...	...	13	8
31.0 N	144.7	1912.3–1916.6	4.3	4 W	...	...	8	9
		1906.6–1916.6	10.0	2 W	...	...	13	9
		1906.7–1912.3	5.6	...	3 N	− .0002	10	6
32.1 N	146.0	1912.3–1916.6	4.3	...	2 S	− .0006	6	7
		1906.7–1916.6	9.9	...	1 N	− .0002	10	7
27.7 N	169.5	1912.3–1915.6	3.3	4 W	...	...	7	15
27.7 N	169.0	1912.3–1915.7	3.4	...	5 S	− .0002	5	8
		1905.9–1915.5	9.6	2 E	...	...	15	11
27.6 N	199.1	1915.5–1921.3	5.8	2 E	...	...	11	15
		1905.9–1921.3	15.4	2 E	...	...	15	15
		1905.9–1915.5	9.6	...	5 S	− .0009	9	6
27.7 N	199.2	1915.5–1921.3	5.8	...	0	− .0003	6	7
		1905.9–1921.3	15.4	...	3 S	− .0002	9	7
27.4 N	134.4	1907.4–1912.3	4.9	1 E	...	...	9	6
26.6 N	131.8	1907.4–1912.3	4.9	...	2 N	+ .0002	7	8
27.0 N	222.2	1906.4–1921.3	14.9	4 E	...	...	10	22
		1908.4–1921.3	12.9	...	0	− .0002	3	14
27.2 N	222.8	1905.7–1908.4	2.7	...	1 S	− .0001	5	3
		1905.7–1921.3	15.6	...	0	− .0002	5	14
		1906.2–1921.3	15.1	...	2 S	− .0002	3	14
		1905.8–1907.7	1.9	0	...	...	13	6
23.1 N	190.2	1907.7–1921.0	13.3	0	...	...	6	20
		1905.8–1921.0	15.2	0	...	...	13	20
		1905.8–1907.7	1.9	...	13 S	+ .0001	6	7
23.1 N	190.1	1907.7–1921.0	13.3	...	4 S	− .0002	7	11
		1905.8–1921.0	15.2	...	5 S	− .0002	6	11
		1906.2–1915.4	9.2	2 E	...	...	4	9
22.2 N	207.4	1915.4–1921.3	5.9	1 E	...	...	9	8
		1906.2–1921.3	15.1	2 E	...	...	4	8

TABLE 32.—*Average Annual Changes for the Pacific Ocean*—Continued.

Latitude	Longitude East of Gr.	Approximate dates	Time-interval	Average annual change			Number of values utilized	
				Declination	Inclination	Horizontal intensity	First date	Second date
°	°		*years*	′	′	*c. g. s.*		
		1906.7–1915.4	8.7	....	0	−0.0003	4	4
22.4 N	207.5	1915.4–1921.3	5.9	....	6 S	+ .0002	4	4
		1906.7–1921.3	14.6	....	2 S	− .0001	4	4
19.1 N	217.7	1906.2–1915.4	9.2	6 E	....	....	9	14
19.0 N	217.4	1906.2–1915.4	9.2	....	4 N	− .0002	9	7
18.3 N	222.2	1915.4–1921.4	6.0	1 E	....	....	12	13
18.0 N	225.0	1915.4–1921.4	6.0	....	4 S	− .0003	6	7
16.5 N	145.3	1906.6–1916.6	10.0	2 W	....	....	5	10
17.0 N	145.0	1906.6–1916.6	10.0	....	2 N	− .0001	6	8
		1907.8–1912.3	4.5	3 W	....	....	4	7
15.0 N	172.8	1912.3–1916.5	4.2	1 E	....	....	7	16
		1907.8–1916.5	8.7	1 W	....	....	4	16
		1907.8–1912.3	4.5	....	6 S	+ .0003	3	5
14.9 N	174.2	1912.3–1916.5	4.2	....	6 S	− .0003	5	7
		1907.8–1916.5	8.7	....	6 S	.0000	3	7
		1908.3–1915.3	7.0	4 E	....	....	7	19
11.3 N	244.6	1915.3–1916.9	1.6	3 E	....	....	19	35
		1908.3–1916.9	8.6	4 E	....	....	7	35
		1908.3–1915.3	7.0	....	2 N	− .0003	9	10
11.4 N	244.6	1915.3–1916.9	1.6	....	4 N	+ .0002	10	21
		1908.3–1916.9	8.6	....	2 N	− .0002	9	21
5.2 N	200.2	1905.9–1921.0	15.1	2 E	....	....	27	15
5.1 N	200.7	1905.8–1921.0	15.2	....	6 S	− .0002	18	7
		1906.3–1921.0	14.7	....	5 S	− .0004	5	7
		1906.5–1907.8	1.3	3 W	....	....	7	5
5.0 N	165.7	1907.8–1915.7	7.9	3 W	....	....	5	30
		1906.5–1915.7	9.2	3 W	....	....	7	30
		1906.5–1907.8	1.3	....	3 N	+ .0006	7	5
4.9 N	166.0	1907.8–1915.7	7.9	....	5 S	− .0002	5	15
		1906.5–1915.7	9.2	....	4 S	− .0001	7	15
4.9 N	232.5	1907.0–1912.6	5.6	7 E	....	....	7	19
4.9 N	232.4	1907.0–1912.6	5.6	....	4 N	+ .0001	7	15
		1915.3–1918.3	3.0	4 E	....	....	28	17
2.7 N	275.4	1918.3–1921.8	3.5	5 E	....	....	17	19
		1915.3–1921.8	6.5	4 E	....	....	28	19
		1915.3–1918.3	3.0	....	19 N	+ .0005	15	9
2.8 N	274.6	1918.3–1921.8	3.5	....	0	− .0010	9	11
		1915.3–1921.8	6.5	....	9 N	− .0003	15	11
		1908.3–1912.6	4.3	4 E	....	....	7	15
0.3 N	246.6	1912.6–1916.9	4.3	3 E	....	....	15	22
		1908.3–1916.9	8.6	4 E	....	....	7	22
		1908.3–1912.6	4.3	....	7 N	+ .0005	9	8
1.0 N	247.0	1912.6–1916.9	4.3	....	4 N	− .0005	8	15
		1908.3–1916.9	8.6	....	6 N	.0000	9	15
2.6 S	178.9	1906.7–1912.4	5.7	1 W	....	....	12	18
3.5 S	178.4	1906.4–1912.4	6.0	....	3 S	− .0001	10	10
		1907.2–1912.4	5.2	....	1 N	− .0005	3	10
5.4 S	258.0	1908.3–1921.7	13.4	4 E	....	....	5	14
5.4 S	258.3	1908.3–1921.7	13.4	....	6 N	.0000	5	7
10.4 S	217.4	1906.1–1912.7	6.6	7 E	....	....	7	10
10.2 S	217.7	1907.1–1912.7	5.6	....	0	− .0002	7	6
		1906.7–1916.5	9.8	3 E	....	....	12	13
12.2 S	191.4	1916.5–1921.5	5.0	2 E	....	....	13	21
		1906.7–1921.5	14.8	2 E	....	....	12	21
		1907.2–1916.4	9.2	....	5 S	− .0004	7	7
		1916.4–1921.5	5.1	....	2 S	− .0002	7	10
12.9 S	192.1	1906.3–1916.4	10.1	....	2 S	− .0003	8	7
		1906.3–1921.5	15.2	....	2 S	− .0003	8	10
		1907.2–1921.5	14.3	....	4 S	− .0003	7	10
13.0 S	273.3	1908.2–1918.2	10.0	2 E	....	....	14	46
12.9 S	274.8	1908.2–1918.2	10.0	....	12 N	+ .0001	13	24
13.3 S	246.2	1912.6–1917.0	4.4	2 E	....	....	18	14
14.3 S	245.9	1912.6–1917.0	4.4	....	3 N	− .0006	7	7

TABLE 32.—*Average Annual Changes in the Pacific Ocean*—Continued.

Latitude	Longitude East of Gr.	Approximate dates	Time-interval	Average annual change			Number of values utilized	
				Declination	Inclination	Horizontal intensity	First date	Second date
°	°		*years*	′	′	*c. g. s.*		
16.2 S	210.6	1912.7–1921.0	8.3	2 E	...	...	11	15
16.7 S	210.6	1912.7–1921.0	8.3	...	2 S	−0.0003	7	8
21.0 S	174.1	1907.4–1912.4	5.0	2 W	...	...	12	19
19.6 S	174.5	1906.4–1912.4	6.0	...	8 S	− .0004	4	15
		1907.9–1912.4	4.5	...	4 S	− .0001	9	15
23.9 S	202.0	1912.8–1921.6	8.8	2 E	...	...	6	12
24.6 S	201.7	1912.8–1921.6	8.8	...	2 S	− .0003	5	6
26.2 S	269.2	1908.2–1913.0	4.8	2 E	...	...	9	11
26.0 S	269.6	1908.2–1913.0	4.8	...	12 N	− .0003	8	8
		1912.5–1916.4	3.9	4 E	...	...	7	11
28.2 S	189.3	1916.4–1921.6	5.2	2 E	...	...	11	16
		1912.5–1921.6	9.1	3 E	...	...	7	16
		1912.5–1916.4	3.9	...	0	− .0006	7	8
28.2 S	189.4	1916.4–1921.6	5.2	...	2 S	− .0003	8	11
		1912.5–1921.6	9.1	...	1 S	− .0004	7	11
		1912.6–1917.0	4.4	4 E	...	...	10	10
		1917.0–1920.9	3.9	0	...	...	10	20
28.6 S	223.1	1912.6–1920.9	8.3	2 E	...	...	10	20
		1912.6–1921.6	9.0	4 E	...	...	10	16
		1917.0–1921.6	4.6	3 E	...	...	10	16
		1912.6–1917.0	4.4	...	6 N	.0000	8	6
		1917.0–1920.9	3.9	...	1 N	− .0002	6	12
29.1 S	223.8	1912.6–1920.9	8.3	...	4 N	− .0001	8	12
		1912.6–1921.6	9.0	...	4 N	− .0002	8	10
		1917.0–1921.6	4.6	...	2 N	− .0004	6	10
29.5 S	258.7	1913.0–1921.7	8.7	2 E	...	...	10	10
29.6 S	257.8	1913.0–1921.7	8.7	...	4 N	− .0005	6	7
		1912.6–1917.0	4.4	0	...	...	9	29
30.1 S	241.6	1917.0–1921.7	4.7	2 E	...	...	29	9
		1912.6–1921.7	9.1	1 E	...	...	9	9
		1912.6–1917.0	4.4	...	0	− .0002	5	14
30.0 S	242.4	1917.0–1921.7	4.7	...	3 N	− .0004	14	9
		1912.6–1921.7	9.1	...	2 N	− .0003	5	9
30.6 S	279.2	1913.0–1918.1	5.1	5 W	...	...	7	37
30.0 S	278.0	1913.0–1918.1	5.1	...	4 N	− .0001	6	17
34.4 S	260.4	1908.1–1912.9	4.8	2 E	...	...	10	24
34.4 S	260.3	1908.1–1913.0	4.9	...	10 N	− .0006	9	18
		1908.1–1912.8	4.7	8 E	...	...	5	13
		1912.8–1917.1	4.3	2 E	...	...	13	21
40.0 S	222.4	1917.1–1920.9	3.8	4 E	...	...	21	14
		1908.1–1917.1	9.0	5 E	...	...	5	21
		1908.1–1920.9	12.8	5 E	...	...	5	14
		1912.8–1920.9	8.1	3 E	...	...	13	14
		1908.1–1912.8	4.7	...	2 S	− .0008	7	8
		1912.8–1917.1	4.3	...	3 N	+ .0004	8	14
40.0 S	221.7	1917.1–1920.9	3.8	...	1 S	− .0002	14	7
		1908.1–1917.1	9.0	...	1 N	− .0002	7	14
		1908.1–1920.9	12.8	...	0	− .0002	7	7
		1912.8–1920.9	8.1	...	1 N	+ .0001	8	7
41.4 S	281.2	1912.9–1918.0	5.1	6 W	...	...	7	10
41.4 S	281.2	1912.9–1918.0	5.1	...	4 S	− .0002	6	6
45.4 S	175.0	1916.1–1920.8	4.7	5 E	...	...	29	14
45.6 S	175.5	1916.2–1920.9	4.7	...	3 S	− .0004	15	7
48.7 S	159.4	1916.1–1920.8	4.7	3 E	...	...	13	6
48.9 S	159.1	1916.1–1920.8	4.7	...	2 S	− .0007	7	4
		1913.1–1916.0	2.9	9 W	...	...	2	10
58.1 S	289.6	1916.0–1918.0	2.0	3 W	...	...	10	14
		1913.1–1917.1	4.0	5 W	...	...	2	12
		1913.1–1918.0	4.9	6 W	...	...	2	14
		1913.0–1916.0	3.0	3 E	...	...	4	11
55.6 S	274.8	1916.0–1918.0	2.0	1 W	...	...	11	11
		1913.0–1917.1	4.1	1 E	...	...	4	8
		1913.0–1918.0	5.0	1 E	...	...	4	11

TABLE 32.—*Average Annual Changes in the Pacific Ocean*—Concluded.

Latitude	Longitude east of Gr.	Approximate dates	Time-interval	Average annual change			Number of values utilized	
				Declination	Inclination	Horizontal intensity	First date	Second date
°	°		*years*		′	*c. g. s.*		
55.9 S	275.3	1913.0–1916.0	3.0	....	4 S	+0.0001	5	5
		1916.0–1918.0	2.0	....	3 N	− .0009	5	8
		1913.0–1917.1	4.1	....	5 N	+ .0001	5	4
		1913.0–1918.0	5.0	....	3 N	− .0003	5	8
57.5 S	289.7	1913.1–1916.0	2.9	....	1 S	− .0003	4	5
		1916.0–1918.0	2.0	....	6 N	− .0001	5	9
		1913.1–1917.1	4.0	....	2 N	− .0002	4	4
		1913.1–1918.0	4.9	....	2 N	− .0002	4	9

STATUS OF THE GENERAL MAGNETIC SURVEY OF OCEAN AREAS.

On Plate 6, the cruises of the *Galilee*, 1905–1908, and the *Carnegie*, 1909–1921, are shown. The dots indicate the land magnetic stations (about 5,000) established by the Department of Terrestrial Magnetism from 1905 to 1924; they are distributed over 115 different countries and island groups, being located especially in regions where no magnetic results, or but an insufficient number, had been obtained previously. The dots in Hudson Strait and Hudson Bay represent the points at which magnetic observations were obtained by the Department in 1914 on the chartered gasoline schooner, the *George B. Cluett*, under the command of W. J. Peters, assisted by D. W. Berky (see pp. 289–313 for special report on this expedition). The dots in Baffin Land, on the Labrador coast, and on the west coast of Greenland represent the points at which magnetic observations were obtained by the *MacMillan Baffin Land Expedition* and the *North Greenland Expedition* in cooperation with the Department, during 1921–1922 and 1923–1924. The dots on the northern coast of Siberia represent the points at which magnetic observations were made by the *Maud Expedition*, under the command of Captain Roald Amundsen, in cooperation with the Department, during 1918–1921.

The directions in which the various passages were made are indicated by arrows. The Arabic numerals 1, 2, and 3 designate, respectively, the three cruises of the *Galilee* (August 1905 to May 1908); the Roman numerals, I, II, III, IV, V, and VI, refer to the six cruises of the *Carnegie* carried out from August 1909 to November 1921. Plate 6 thus shows the status of the general magnetic survey of the ocean areas as represented by the cruises of the two vessels, the *Galilee* and the *Carnegie*, from August 1905 to November 1921.

Table 33 shows for each cruise of the *Galilee* and of the *Carnegie* the number of days at sea,[1] the length of the cruise in nautical miles, and the number of observed values of the magnetic declination, inclination, and intensity of the Earth's magnetic field. The subsequent columns give the average time-intervals, as well as the average distance apart, between the observations. The entries in the bottom row of the table summarize the work of the two vessels from August 1905 to November 1921. It will be seen that the aggregate length of all the cruises of the *Galilee* and *Carnegie* through November 1921 is 316,536 nautical miles.

Table 34 shows for each ocean the number of miles traversed, the number of observed values of the magnetic elements, and the number of cruise-intersections which have been utilized for the determination of the annual-change data (see pp. 185–191).

[1] In the case of the *Galilee* work, to the number of days at sea were added the days spent in harbor swings.

TABLE 33.—*Summary of the Ocean Magnetic Work of the Galilee and the Carnegie, 1905–1921.*

Vessel and cruise	Number		Number of observed values			Average time-interval			Average distance apart		
	Days	Miles	Decl'n	Incl'n	Hor. int.	De-cl'n	In-cl'n	Hor. int.	De-cl'n	In-cl'n	Hor. int.
						days	*days*	*days*	*miles*	*miles*	*miles*
Galilee, Cruise I, 1905	92	10,571	74	58	59	1.2	1.6	1.6	143	182	179
Galilee, Cruise II, 1906	168	16,286	95	88	91	1.8	1.9	1.8	171	185	179
Galilee, Cruise III, 1906–08	334	36,977	156	169	171	2.1	2.0	2.0	237	219	216
Totals for *Galilee*	594	63,834	325	315	321	1.8	1.9	1.9	196	203	199
Carnegie, Cruise I, 1909–10	96	9,600	98	68	69	1.0	1.4	1.4	98	141	139
Carnegie, Cruise II, 1910–13	798	92,829	858	648	643	0.9	1.2	1.2	108	143	144
Carnegie, Cruise III, 1914	84	9,560	108	81	80	0.8	1.0	1.0	89	118	119
Carnegie, Cruise IV, 1915–17	487	63,400	869	480	479	0.6	1.0	1.0	73	132	132
Carnegie, Cruise V, 1917–18	122	13,195	224	116	116	0.5	1.1	1.1	59	114	114
Carnegie, Cruise VI, 1919–21	487	64,118	834	439	439	0.6	1.1	1.1	77	146	146
Totals for *Carnegie*	2,074	252,702	2,991	1,832	1,826	0.7	1.1	1.1	84	132	132
Totals for *Galilee* and *Carnegie*	2,668	316,536	3,316	2,147	2,147	0.8	1.2	1.2	96	147	147

The total number of days the *Galilee* was in commission during the period August 1, 1905, to May 31, 1908, counting out the two intervals between cruises 1 and 2 and between cruises 2 and 3, with the exception of the days spent in harbor swings, is 897. Since 594 days were spent at sea and in harbor swings, the remaining days, 303, are to be ascribed to the time spent in port, making shore observations and comparisons of instruments, computations, repairs, and outfitting.

TABLE 34.—*Summary of Ocean Magnetic Work, Galilee and Carnegie, 1905–1921.*

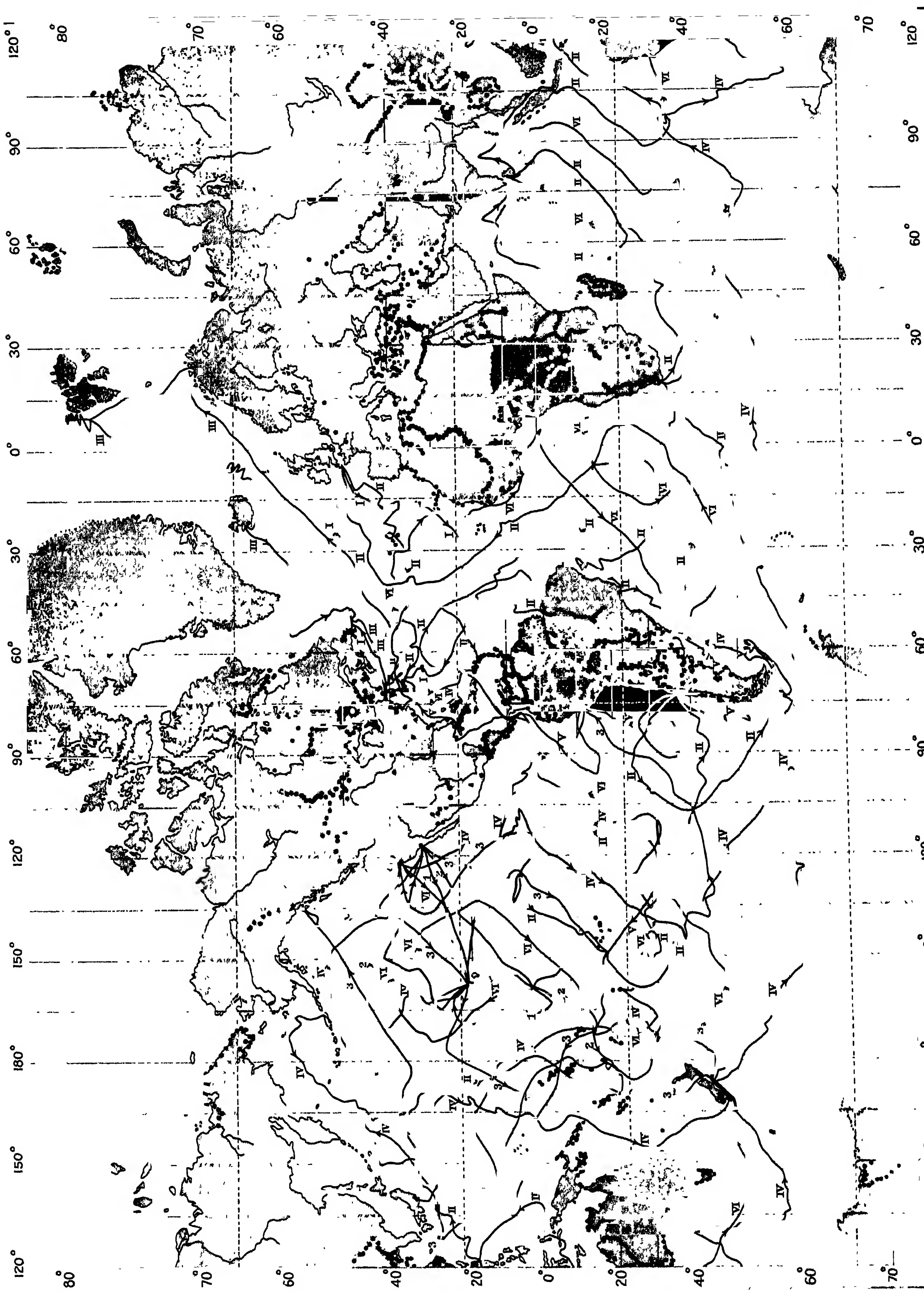
Ocean	Number of nautical miles	Number of observed values		Cruise inter-sections used for annual-change data
		Declination	Inclination and horizontal intensity	
Pacific	181,423	1,800	1,183	47
Atlantic	92,053	1,039	682	27
Indian	43,060	477	282	7
Total	316,536	3,316	2,147	81

The total number of days the *Carnegie* was in commission from September 1, 1909, to November 12, 1921, counting out the periods February 18 to June 19, 1910, December 20, 1913, to June 7, 1914, October 22, 1914, to March 5, 1915, when the vessel was at Brooklyn, March 3, 1917, to December 4, 1917, when the vessel was at Buenos Aires, June 10, 1918, to October 9, 1919, when the vessel was at Washington and at Baltimore, is 3,267 days. Since 2,074 days were spent at sea, the remaining days, 1,193, are to be ascribed to the time consumed in ports in shore observations and comparisons of instruments, computations, repairs, and outfitting.

It is thus seen that about two-thirds of the time the vessel was in commission were spent at sea, in the case of both the *Galilee* and the *Carnegie*.

It is seen from Table 33 that the average time-intervals and the average distances apart for the *Galilee* work has been decreased by about 40 per cent in the *Carnegie* work. The increased efficiency, or productiveness, has resulted from the fact that the *Carnegie*

PLATE 6



is a nonmagnetic vessel and because of the steady improvement in the instrumental appliances and observational methods.

MAPS SHOWING DISTRIBUTION OF OCEAN MAGNETIC STATIONS, 1905 TO 1921.

Plates 7 to 11 of the North Pacific, South Pacific, North Atlantic, South Atlantic, and Indian oceans on Mercator's projection show the locations of all the ocean magnetic stations occupied by the *Galilee*, 1905–1908, and by the *Carnegie*, 1909–1921. The stations are joined to indicate the cruise to which they belong and the different cruises are designated as follows: The three cruises of the *Galilee* are marked by Arabic numerals 1, 2, and 3; the six cruises of the *Carnegie* by Roman numerals I, II, III, IV, V, and VI. A station where the magnetic declination was determined is designated by a cross, and a station where the horizontal intensity and inclination were determined is designated by a circle. (Plates 7 to 11 will be found in the pocket at the back of this volume.)

These maps are useful in showing the actual distribution of magnetic stations at sea, for grouping stations at cruise-intersections for the determination of secular variation, and in planning future cruises to fill in regions where stations are few and scattered and to reoccupy former stations as closely as possible to increase our information regarding secular change.

REQUIREMENTS FOR FUTURE OCEAN WORK.

The discussion of the secular variation of the magnetic elements at sea emphasized the need of securing additional information regarding these changes. Future cruises should be arranged to follow as closely as possible the tracks of former cruises, instead of placing dependence largely upon frequent track-intersections for secular-variation data. Thus the fullest possible information as to secular changes will be obtained.

While more information on the distribution and the secular variation in the Earth's magnetism is required for practical purposes, yet future magnetic and electric work at sea is far more necessary for the advancement of theoretical studies. The fields of theoretical investigation for which additional data are needed include:

1. *Terrestrial Magnetism.*
   (*a*) Determination of secular variations or progressive changes of the Earth's magnetic field involving particularly their accelerations, which the accumulated data indicate may not be extrapolated safely over periods as long as five years; accurate data for a number of epochs are necessary to advance the investigation of causes producing and governing these progressive changes.
   (*b*) The study of regions of local disturbance and particularly those indicated by the previous work of the *Carnegie* over "deep-sea" areas, including accompanying determinations of gravity and of ocean depths.
   (*c*) The determination of additional distribution data in some large areas not already covered.
2. *Atmospheric Electricity.*
   (*a*) Additional determinations of changes in the values of the atmospheric-electric elements with geographic position; such distribution data are needed in the further investigations of the origin and maintenance of the Earth's electric charge and of the relations to its magnetic condition.
   (*b*) Further widely distributed determinations of the diurnal variations in atmospheric electricity particularly to confirm the discovery that such variations in the potential gradient progress with universal time, a deduction first indicated from results obtained on the *Carnegie;* sea conditions for such work are superior to those on land, where variable meteorological conditions and topography mask the true characteristics of the phenomena.
   (*c*) Determinations and investigations of Earth-currents.

Since the future ocean magnetic work may be less intensive as regards the distribution of magnetic data and attention may be directed more particularly to obtaining secular-variation information, more time will be available for atmospheric-electric work and for other oceanographic studies which may be undertaken with profit.

ATMOSPHERIC - ELECTRIC RESULTS OBTAINED ABOARD THE CARNEGIE 1915 - 1921

By J. P. Ault and S. J. Mauchly

ATMOSPHERIC-ELECTRIC RESULTS OBTAINED ABOARD THE CARNEGIE, 1915-1921.

Based on Observations and Reports by J. P. AULT, H. M. W. EDMONDS, H. R. GRUMMANN, H. F. JOHNSTON, B. JONES, I. A. LUKE, S. J. MAUCHLY, J. M. MCFADDEN, A. D. POWER, W. F. G. SWANN, and A. THOMSON.

INTRODUCTION.

The present report is concerned with the results of atmospheric-electric observations made on the *Carnegie* during cruises IV, V, and VI, 1915 to 1921. It is a continuation of the report contained in Volume III, Researches of the Department of Terrestrial Magnetism (pp. 361–422), to which reference may be made for details of methods, instruments, and observational program.

When Volume III was published, Cruise IV had not yet been completed, hence the results of this cruise were only partially reported. In order to include in one volume all the results of Cruise IV, those published in Volume III are repeated in the present report. This was advisable, also, because of certain numerical changes in the results arising from revisions and the adoption of final constants for the period 1915–1921 at the conclusion of Cruise VI, after final standardization observations and experimental laboratory investigations of the instruments and methods.

During the period covered by this report there was a steady improvement in instruments and methods, as observers gained experience and as a result of discussions and analyses carried out at the office. Increasing attention was paid to securing diurnal-variation results, especially during Cruise VI, as the importance of this part of the observational program was recognized.

In view of the difficulties of making atmospheric-electric observations at sea, on account of motion of vessel, dampness, flying spray, and the heavy seas which at times placed all the instruments out of commission, mention should be made of the zeal and persistence of the observers who had charge of the atmospheric-electric program. Special credit is due to H. F. Johnston, who was in charge of the atmospheric-electric work when the new instruments and methods were inaugurated during Cruise III, and during Cruise IV up to May 1916; he was assisted by I. A. Luke during all this time. Mr. Johnston was particularly successful in securing results during the abnormal conditions encountered on the cruise around the South Pole, when storms and gales occurred almost daily and there was some sort of precipitation, rain, snow, fog, or mist, during 100 out of 118 days. In May 1916, B. Jones was placed in charge of the atmospheric-electric work and continued in charge during the remainder of Cruise IV and also during Cruise V. He was assisted by I. A. Luke to September 1916, A. D. Power from November 1916 to March 1917, and J. M. McFadden during Cruise V from December 1917 to June 1918. During Cruise VI, A. Thomson was in charge of the atmospheric-electric work, assisted by H. R. Grummann; Captain Ault assisted Mr. Thomson in the

heavy diurnal-variation program from September 1920 to the end of Cruise VI, relieving Mr. Grummann of this feature of the work.

The final results of the regular daily observations and of the special diurnal-variation observations are set forth in the Table of Results (pp. 212–265) in chronological order, separated according to cruises and oceans. They were compiled by J. P. Ault and S. J. Mauchly, assisted by Miss Mary C. Parker. Reference should be made to the constructive aid rendered by those whose names do not appear specifically elsewhere: J. A. Fleming, assistant director; C. Huff, shop foreman; and C. A. Kotterman, laboratory aid.

OUTLINE OF OBSERVATIONS ON CARNEGIE CRUISES, 1915-1921.

OBSERVATIONS ON CRUISE IV, 1915–1917.

J. P. AULT in Command.

The *Carnegie* started from Brooklyn on her fourth cruise (see Fig. 4) March 6, 1915, stopping first at Gardiners Bay until March 9, to make her usual "swinging-ship observations," and arrived at Cristobal, Canal Zone, on March 24, 1915. She next passed through the Panama Canal; leaving Balboa April 12, she sailed for Honolulu, arriving there May 21, 1915. She left Honolulu on July 3 and arrived at Dutch Harbor, Alaska, July 20, from which port she sailed August 4 for Lyttelton, New Zealand, arriving there November 3. Leaving Lyttelton December 6, 1915, a circumnavigation of the south polar regions was made, between the parallels 50° and 60° south, the *Carnegie*

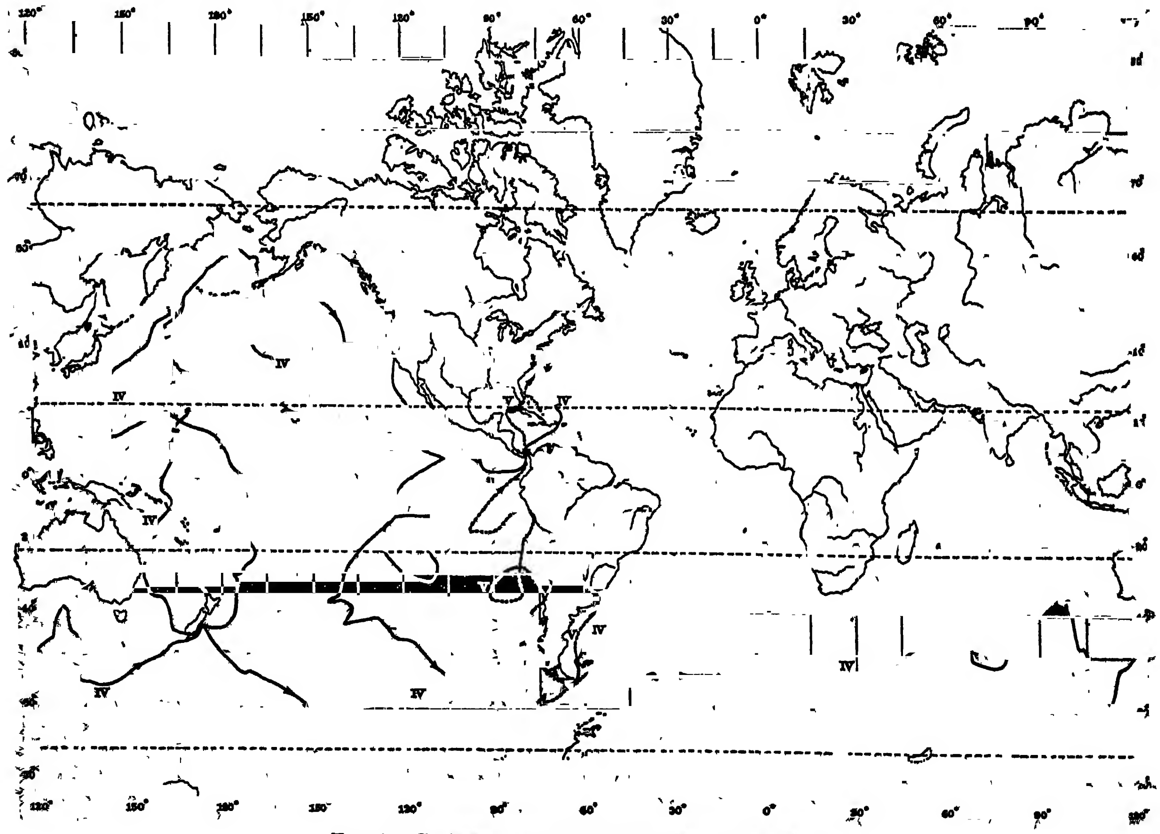


FIG. 4.—Cruises IV and V of the *Carnegie*, 1915–1918.

returning to Lyttelton April 1, 1916, her only stop during the trip around the world being at South Georgia, January 12–14, 1916.

On May 17, 1916, the *Carnegie* again left Lyttelton, sailing for Pago Pago, Samoa, arriving there June 7. Sailing for Guam June 19, the latter place was reached July 17. On August 7 the vessel left Guam for San Francisco, where she arrived September 21. Leaving San Francisco November 1, Easter Island was reached December 24. After a stay of one week, the *Carnegie* sailed for Cape Horn and Buenos Aires January 2, 1917, the latter port being reached March 2, 1917. Here Cruise IV was concluded and, because of the entry of the United States in the world war, the vessel remained at Buenos Aires for nine months. Cruise IV is shown in Figure 4.

On the completion of the work of Cruise III it was felt, as a result of the experience gained, that the time had come when a more ambitious program of atmospheric-electric work could be undertaken with hope of success, and to this end the atmospheric-electric equipment was considerably increased. Also, a special atmospheric-electric house was built on the vessel for a more permanent installation of the instruments.

The design of the methods of measurements and the organization of the general scheme of procedure in the atmospheric-electric work were initiated by W. F. G. Swann. In the work connected with the installation of the instruments, and in the experimental work prior thereto, he was assisted by S. J. Mauchly and H. F. Johnston, the observer to whom had been assigned the atmospheric-electric work on the cruise. Messrs. Swann and Mauchly accompanied the vessel from Brooklyn as far as Gardiners Bay, in order to complete the installations and tests of the new instruments. S. J. Mauchly continued with the *Carnegie* as far as Balboa to complete the remaining adjustments found necessary.

The observations from New York to Cristobal were made by S. J. Mauchly and H. F. Johnston; from Balboa, April 12, 1915, until the return of the vessel to Lyttelton, New Zealand, April 1, 1916, after her sub-Antarctic circumnavigation cruise, they were made by Observer H. F. Johnston, assisted by Observer I. A. Luke; from Lyttelton, May 17, 1916, to San Francisco, September 21, 1916, they were made by Observer B. Jones, assisted by Observer I. A. Luke; from San Francisco, November 1, 1916, to Buenos Aires, March 2, 1917, they were made by Observer B. Jones, assisted by Observer A. D, Power.

For a discussion of details of instruments and methods employed in the atmospheric-electric work during cruises IV, V, and VI, and for specimens of observations and computations, reference may be made to Volume III (pp. 377–401).

OBSERVATIONS ON CRUISE V, 1917–1918.

H. M. W. EDMONDS in Command.

The *Carnegie* started from Buenos Aires, Argentina, December 4, 1917, and, proceeding by way of Cape Horn, reached Talcahuano, Chile, January 11, 1918. Sailing for Callao January 23, she reached the latter port February 22. Leaving Callao March 29, Balboa, Canal Zone, was reached April 24. Passing through the Panama Canal May 2, the *Carnegie* remained at Cristobal until May 11, when she sailed for Newport News, arriving June 4. June 8 the vessel left Newport News, and, after "swinging-ship operations" in Chesapeake Bay, arrived at Washington June 10, 1918. Cruise V is shown in Figure 4.

The atmospheric-electric observations during this cruise were made by Observer B. Jones, assisted by Observer J. M. McFadden. The methods and instrumental equipment remained the same as those in use during Cruise IV.

OBSERVATIONS ON CRUISE VI, 1919–1921.

J. P. AULT in Command.

At the close of the world war plans were made to continue the ocean work of the *Carnegie* and, after being repaired and outfitted, the vessel sailed from Washington October 9, 1919, on Cruise VI. After "swinging-ship operations" in Chesapeake Bay and at Solomons Island, Old Point Comfort was reached October 15. Sailing from Old Point Comfort October 19, the following ports were visited, with the dates of arrival and departure as indicated: Dakar, November 22–26, 1919; Buenos Aires, January 19–February 21, 1920; St. Helena, March 27–April 3, 1920; Cape Town, April 24–May 20, 1920; Colombo, June 30–July 24, 1920; Fremantle, September 1–October 1, 1920; Lyttelton, October 21–November 19, 1920; Papeete, Tahiti, December 24, 1920–January 3, 1921; Fanning Island, January 14, 1921; San Francisco, February 19–March 28, 1921; Honolulu, April 12–28, 1921; Penrhyn Island, June 12, 1921; Manihiki Island, June 15, 1921; Pago Pago, Samoa, June 20–28, 1921; Apia, Samoa, June 29–July 25, 1921; Rarotonga, August 14–15, 1921; Balboa, Canal Zone, October 7–20, 1921; Old Point Comfort, November 6, 1921; Washington, November 10, 1921. Cruise VI is shown in Figure 5.

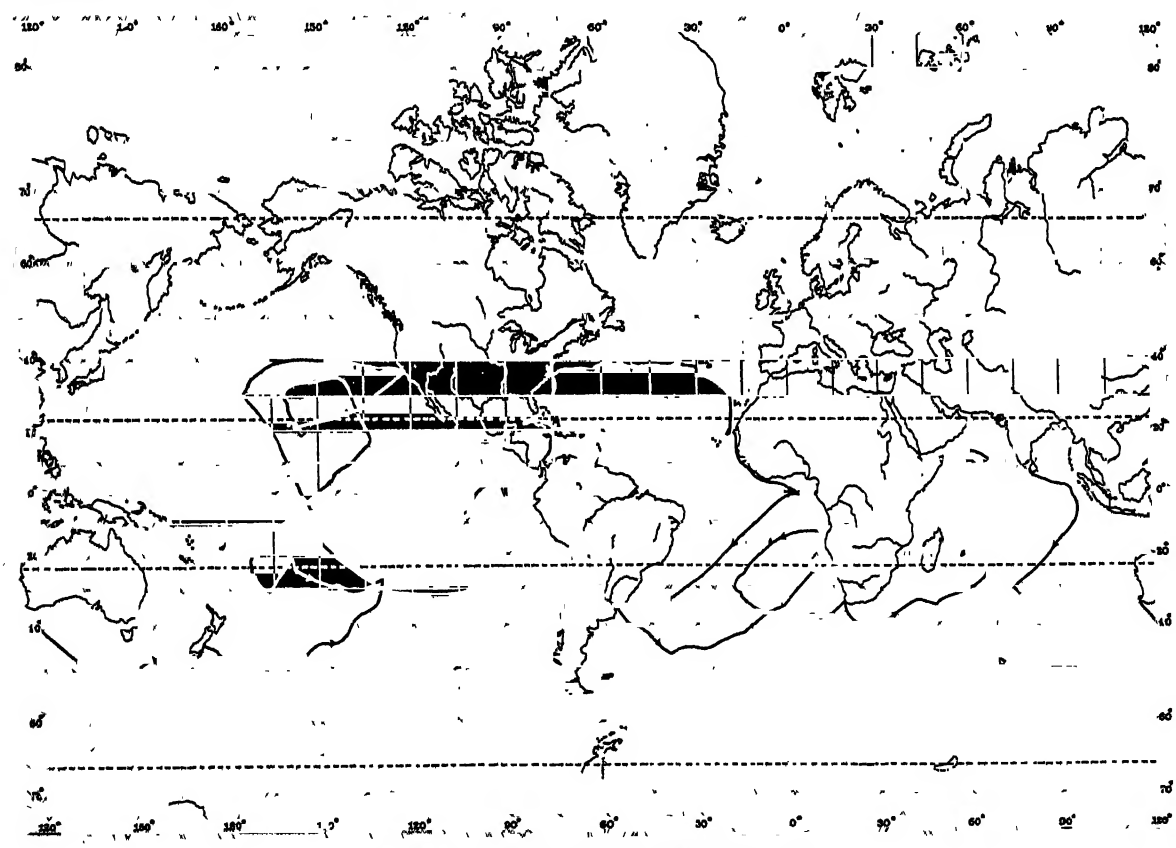


FIG. 5.—Cruise VI of the *Carnegie*, 1919–1921.

The observations during Cruise VI were made by Observer Thomson, assisted by Observer Grummann; after September 1920 Captain Ault took part in the diurnal-variation observations in place of the latter.

During this cruise the radioactive content of sea-water was not determined and the diurnal-variation observations included measurements of the conductivity as well as of the potential gradient, ionic numbers, and penetrating radiation.

INSTRUMENTS, OBSERVATIONAL PROCEDURE, AND CONSTANTS, 1915-1921.

The instrumental equipment and observational procedure throughout the period 1915–1921 were essentially as described and discussed by W. F. G. Swann in Volume III (pp. 377–401). Similarly, the forms for recording both the observations and computations remained throughout cruises IV, V, and VI as shown in the above reference from Volume III.

The instruments designed and constructed by the Department, unless otherwise noted, and used on cruises IV, V, and VI (see Plates 12 and 13) were the same throughout, except for modifications made from time to time as the work progressed (see pp. 202–204). They were as follows: (1) Conductivity apparatus 3 (designation CA3) with gimbal rings and mounting and direct-current motor; (2) ion counter 1 (IC1) with gimbal rings and mounting and appurtenances; (3) penetrating-radiation apparatus 1 (PRA1) with gimbal rings and mounting, and appurtenances; (4) potential-gradient apparatus 2 (PG2) complete with appurtenances and mounting; (5) radioactive-content apparatus 4 (RCA4) with gimbal rings and mounting, water-dropping apparatus, direct-current motor, ionizing chamber, anemometer, and other appurtenances; (6) accessories manufactured by Weston Electrical Instrument Company, Günther and Tegetmeyer, Spindler and Hoyer, Cambridge Instrument Company, Gambrell Brothers, Pyrolectric Instrument Company, Chloride of Silver Dry Cell Battery Company, and others; Gerdien condensers 4 (until April 1915 and from April to October 1916) and 5 (from October 1916 to end of cruise); C. I. W. single-fiber electrometers 12, 14, and 15; Braun electroscope 1437; Wulf bifilar electrometers 3537 (to July 1921), 3995 (repaired in instrument shop of the Department during October 1916), and 4357 (to July 1921); various high-resistance rheostats; batteries of Cadmium and Eveready dry-cells during cruises IV and V, and of silver-chloride dry-cells during 1919–1921; voltmeters; volt-ammeters; potentiometers; radium and ionium collectors; miscellaneous equipment including nonmagnetic clamps, special insulators, small tools, and stock of pure sulphur.

Before the *Carnegie* started on her sixth cruise, a careful study was made of the various official reports and correspondence relating to the atmospheric-electric work of cruises IV and V to determine what repairs were needed and what improvements could be made in the time available. An attempt was made to eliminate all avoidable difficulties to the end that the observer should have more of his time and energy available to cope with the inherent and unavoidable difficulties attending observations at sea.

A great advance in this direction resulted from the installation of a *storage battery* which furnished the power for driving the fans of the conductivity apparatus and the radioactive-content apparatus. This eliminated the periodic and troublesome renewals which it had been necessary to make during cruises IV and V, when primary batteries were used to operate the fan motors.

Another significant improvement consisted in the adoption and use of *improved potential batteries*. The experience of the earlier cruises had shown that one of the most troublesome problems associated with atmospheric-electric work on shipboard was that of suitable potential batteries for the various instruments. This is especially true where the observations between ports extend over several months, as is sometimes the case on the *Carnegie*. For reasons pointed out by Swann (Vol. III, p. 378), the Krüger type of batteries was not found satisfactory. Consequently, potential batteries composed of ordinary flashlight cells were used throughout most of cruises IV and V. These proved to be much superior to batteries of the Krüger type, but for the work under consideration they are open to the serious objection that their internal resistance increases rather rapidly with age, thus introducing the very difficulties which render the Krüger type unsatisfactory. Further, experience both on the *Carnegie* and in the atmospheric-electric observatory of the Department at Washington has shown that such batteries required rather frequent renewals for satisfactory service on account of the corrosion of the zinc element even when they are on open circuit. In fact, it was found necessary during the fourth and fifth cruises to send renewals direct from America to most of the *Carnegie's* ports of call, and even with this precaution some cells were in poor condition by the time they reached the vessel. Laboratory experiments and actual use in the Department's field work and in the atmospheric-electric observatory at Washington had shown chloride-of-silver dry cells to be free from both of the objections just cited. Hence it was decided to use chloride-of-silver dry-cell batteries with the atmospheric-electric apparatus aboard the *Carnegie* during her sixth cruise.

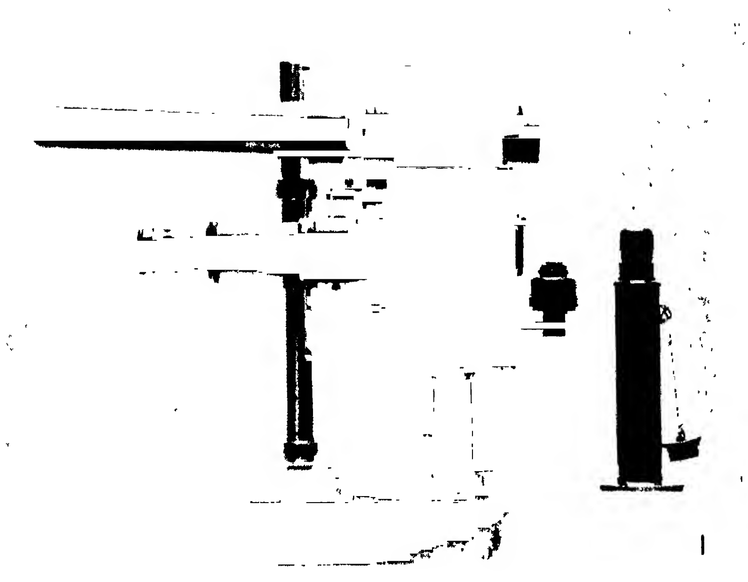
As supplied to the vessel for this purpose, each battery unit consisted of 50 cells connected in series and mounted in a suitable box. As a precaution against accidental short-circuit, each 50-cell unit was placed in series with a built-in resistance coil of 10,000 ohms, and the entire unit embedded in paraffin for protection against moisture. The performance of these batteries proved to be very satisfactory, and the original supply served throughout the 25 months of Cruise VI.

While, as already stated, the atmospheric-electric equipment aboard the *Carnegie* was essentially the same for the fourth, fifth, and sixth cruises, all the instruments were thoroughly overhauled and put in good repair prior to the beginning of Cruise VI. During this work advantage was taken of the opportunity for incorporating various improvements suggested by the atmospheric-electric observers of the two preceding cruises, together with certain modifications suggested by the general progress in instrument construction.

INSTRUMENT IMPROVEMENTS FOR CRUISE VI.

A brief summary of the more important changes introduced in the several instruments follows:

Potential-gradient apparatus 2.—By the end of Cruise V the parasol-shaped prime conductor had become considerably corroded by the action of salt spray, and also somewhat distorted. Since experience had shown the main supporting rod to be rather too light, this part of the apparatus was entirely rebuilt, using a thicker walled tube of



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ATMOSPHERIC-ELECTRIC INSTRUMENTS USED ON THE CARNEGIE, CRUISE VI.

1. Potential-gradient electrometer, showing handle for raising prime conductor.
2. Potential-gradient electrometer with cover remove showing insulated mountings for prime-conductor
3. Improved type of bifilar electrometer with appurtenances.
4. Observer using potential-gradient apparatus, moun stern rail, with prime conductor raised.

somewhat larger diameter. All essential dimensions were, however, retained as they had been during cruises IV and V in order that the reduction-factor of the apparatus might not be appreciably altered. Minor changes were also made to facilitate the removal of the electrometer and for the more adequate safeguarding of the insulation against moisture (see Pl. 12, Figs. 1, 2, and 4).

Conductivity apparatus 3.—This apparatus, too, was almost entirely rebuilt, partly because its original wooden case had begun to deteriorate and because it was desired to provide a more rigid mounting for the motor and gears which operate the fan. To this end there was constructed a new housing of sheet aluminum (see Pl. 13, Fig. 1), which proved to be a great advantage over the original wooden housing. Although the bifilar electrometer associated with this apparatus was originally provided with a gimbal system, as described in Volume III, this was removed about the middle of Cruise IV, as it was thought by the observer to be an unnecessary complication. Since the observers of cruises IV and V were agreed on the point that a gimbal system was unnecessary with the Wulf bifilar electrometer, no such mounting was provided for the apparatus as used on the sixth cruise.

Similarly the two guard-ring insulators described in Volume III (pp. 386–387) were found by the observers to be less satisfactory than had been anticipated, and on their suggestion were not included in the arrangement used during the sixth cruise.

However, the air-flow tube, central cylinder, and electrometer were not altered, and the apparatus, therefore, remained in all essentials as on cruises IV and V, as regards its fundamental dimensions. The tube leading from the electrometer to the air-flow tube was replaced by a new tube which provided a better support for the central cylinder, better protection for the insulators mounted therein, and greatly facilitated removal of the electrometer for such adjustments as are necessary from time to time. While the introduction of this new tube and insulator system somewhat increased the total capacity of the apparatus, this disadvantage was more than offset by the advantages secured.

Ion counter 1.—Certain slight changes were made within the air-flow tube of the ion counter in order to secure better protection for the essential insulators, and a new funnel was supplied which could always be turned to receive the wind in order to prevent aspiration up the tube during moderate and heavy winds. Figure 4 of Plate 13 shows the ion counter and its supporting gimbal system.

Radioactive-content apparatus 4.—The entire central cylinder of the collecting system was reconstructed to provide better insulation and to expedite the mounting and removal of the copper foil upon which the radioactive deposits are collected. Figure 2 of Plate 13 shows the central cylinder of the collecting system as used on the sixth cruise. The ionization apparatus (see Pl. 13, Fig. 5) for the decay-curve observations gave some trouble in the earlier cruises because of insufficient clearance between the upper part of the electrometer and the gimbal rings which support the electrometer and chamber. In order to improve this condition the length of electrometer cap or section of tube connecting the ionization chamber to the electrometer was increased by 2.5 cm. to give adequate clearance between electrometer and gimbals during rolling of the ship.

Penetrating-radiation apparatus 1.—The only change of importance here was the lengthening of the electrometer cap similar to that described in the preceding paragraph for the ionization chamber of the radioactive-content apparatus. Special provision was also made to insure more adequate sealing of the ionization chamber against air leakage. Figure 3 of Plate 13 shows this instrument.

General remarks.—For all instruments advantage was taken, wherever possible, of opportunity to improve convenience of operation and to provide more adequate means of maintaining good insulation.

The system for calibrating the single-fiber electrometers has been essentially the same throughout the three cruises under discussion, except that the use of the three separate potentiometers described in Volume III was discontinued after the fifth cruise. During all of Cruise VI only one potentiometer-system was used, this being connected to the observatory voltmeter and to all three electrometers by a suitable set of reversing switches.

CONCERNING THE METHOD OF APPLYING THE POTENTIAL DIFFERENCE BETWEEN THE PLATES OF THE EINTHOVEN ELECTROMETERS.

During the first half of Cruise IV the Einthoven single-fiber electrometers of ion counter 1, penetrating-radiation apparatus 1, and the ionization chamber of radioactive-content apparatus 4 were each provided with a separate battery of Krüger and, later, flashlight cells for supplying the required plate-potentials and for maintaining the air-flow tube of the ion counter and the walls of the ionization chambers at suitable potentials. The poles of each battery were connected to the potential-plates of the corresponding electrometer and its midpoint to the earthed case of the electrometer. Under these conditions, if one-half of the battery suffers a fluctuation which is not experienced by the other half, a movement of the fiber will result. Also, unless considerable care was taken to insure that both plates were connected simultaneously to the poles of the battery, the fiber was sometimes deflected so vigorously that it would adhere to one of the plates. To eliminate these difficulties, the arrangement represented in Figure 6

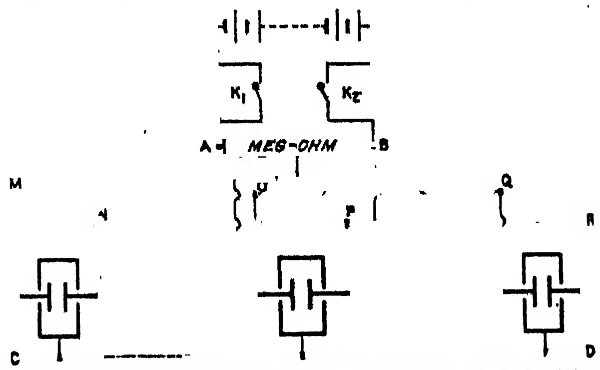


FIG. 6.—Battery Circuit in Atmospheric-Electric Observing-House.

was devised by Swann for use during the latter part of Cruise IV and on Cruise V. The same principle was employed throughout Cruise VI and may be briefly described as follows:

A battery of at least 200 volts is connected to the terminals A and B of a well-insulated megohm whose midpoint is connected to the earthed cases of the three electrometers to be served. Two distributing wires MQ and NR are connected to A and B, respectively, and serve to maintain the plates of all the electrometers at the potential differences existing between the terminals of the megohm. Under these conditions the difference in potential between one plate and the case of its electrometer must always be equal to the difference in potential between the case and the other plate, even though the terminal potential-difference of the battery may fluctuate. Further, with this arrangement, when the electrometers are once adjusted so that the fibers do not move when the potential difference is applied to the plates, this adjustment will be approximately preserved for all applied potentials. Whenever either key of the battery circuit is open all plates are at the same potential and, therefore, earthed, since they are connected together through the megohm. When the battery circuit is closed, all plates immediately assume their proper potentials and the fiber shows no movement if it has been properly adjusted. The potentials required for the air-flow cylinder of the ion

counter and for the ionization chambers connected to the two other electrometers are also supplied by the same distribution wires as are used for the plate-potential.

It is to be noted that all battery terminals, switches, and insulating supports are sulphur-insulated, since sulphur has been found by far the most satisfactory insulating substance for use where spray is encountered or where the air is unusually humid.

INSTRUMENTAL CONSTANTS AND STANDARDIZATIONS.

Electrical capacities.—To a large extent the atmospheric-electric observations made over the oceans prior to the *Carnegie's* fourth cruise were capable of giving relative values only. This was especially true for observations of potential gradient and radioactive content. At the beginning of the fourth cruise plans and preparations were made for the reduction of all atmospheric-electric data obtained to their respective absolute values in order to facilitate the intercomparison of data and meet the requirements of quantitative investigations. In accordance with this plan, numerous determinations of the electrical capacities of the conductivity apparatus, ion counter, penetrating-radiation apparatus, and radioactive-content apparatus used aboard the *Carnegie* were made from time to time during the three cruises under consideration. However, an examination of the accumulated data showed for each instrument a considerable variation in the results obtained for identical conditions, not only between observations made by different observers, but also between those of the same observer. After a careful consideration of the methods used and all the data available regarding the observations in question, the conclusion was reached that the importance of eliminating the effects of contact potentials and the adequate screening of all connections against inductive effects had not, in most cases, been fully appreciated. Thus one was not justified in taking mean values of all determinations for the respective capacities, since this might lead to results which were considerably in error.

Accordingly, after the completion of the sixth cruise, the matter of making reliable measurements of capacities ranging from 10 to 25 electrostatic units was taken up as a laboratory problem. Since the observations on the ship were made in the customary manner by means of a Gerdien variable air-condenser, the problem resolved itself into a study of the precautions necessary for obtaining, by this method, capacity determinations of the desired precision and accuracy for the small capacities here involved. It was found that accurate and verifiable results are obtainable by the variable-condenser method provided: (1) that the variable condenser and the apparatus whose capacity is to be measured be rigidly mounted close together in such a manner as to prevent any relative motion whatever between them during the observations for a given determination; (2) that the connection between the condenser and apparatus be as short as practicable and thoroughly protected by earthed metal screens against possible inductive effects due to the proximity of the observer or charged conductors; (3) that a form of contactor be employed which eliminates the possibility of bound charges remaining on the system to be earthed and enables one to make the necessary operations without any displacement of the connection between condenser and apparatus; (4) that determinations be made with both signs to eliminate contact effects in either the condenser or the apparatus; and (5) that all condenser adjustments be made by means of a low-pitch adjusting screw and the initial and final condenser adjustments be both made in the same direction so as to avoid backlash. A special contactor was designed to meet the third requirement, after which it was found possible to determine capacities of the order of 10 centimeters with accuracy better than 5 per cent with ordinary precautions. However, with an electrometer of suitable sensitivity and with a more-highly-refined technique 10-observation means may be obtained whose probable error is of the order of 1 per cent.

Following the development of the equipment and technique required for capacity determinations of the desired accuracy, the capacity of each apparatus was carefully determined for each of the different arrangements in which it was used during the years 1915–1921. Thus, so far as the capacity values are concerned, all results given in the table of "Final Results of Ocean Atmospheric-Electric Observations on the *Carnegie*, 1915–1921" for any given atmospheric-electric element are on the same absolute basis throughout the period covered by the table, and the different atmospheric-electric quantities measured are given on the same absolute-value standard with an accuracy of about 2 or 3 per cent. This, of course, does not take into account the accidental errors of the atmospheric-electric observations which were often made under trying and unfavorable conditions.

The capacity of the central cylinder of Gerdien conductivity apparatus 3 and that part of its supporting rod which is exposed to air-flow during conductivity observations was redetermined by S. J. Mauchly in 1924, employing the method used by Hewlett[1] in 1914 with improvements as to insulation, experimental arrangement, and technique. For example, as in Hewlett's experiment, the supporting rod of the central cylinder was replaced by a duplicate which was cut off at the exact level at which it passed through the wall of the air-flow cylinder. But the silk fibers used by Hewlett for supporting the central cylinder were replaced by two fine quartz fibers which were attached to the ends of the cylinder by small bits of sealing wax and passed vertically through two small holes drilled through the upper part of the air-flow tube to a supporting device. By means of this device the central cylinder could be raised to a height of several centimeters above its normal position and again definitely placed in its normal position coaxial with the outer cylinder and in contact with the electrometer after the latter had been earthed, or vice versa. Thus practically all difficulty and uncertainty was eliminated from the necessary manipulations of the experiment. The insulation provided by the quartz fibers, too, was exceptionally good. The mean of 20 well-controlled observations gave a value of 6.14 E. S. U., the maximum departure of any one measurement from this mean amounting to less than 3.0 per cent. This is in good agreement with Hewlett's result, which was 5.94 for a mean of six results, the maximum departure of any one determination from this mean amounting to 4.5 per cent. Since the 1924 observations were carried out under more favorable conditions and in a manner capable of giving a somewhat greater accuracy than those of 1914, the value of C_2, the part of the insulated system exposed to the air-flow, has been taken as 6.14 E. S. U. throughout cruises IV to VI.

Summary of results of capacity determinations for Cruise VI.—The capacities adopted for the several instruments as used for Cruise VI were as follows: Conductivity apparatus 3, $C_1=14.55$ E. S. U. and $C_2=6.14$ E. S. U.; ion counter 1, $C=23.5$ E. S. U.; penetrating-radiation apparatus 1, $C=9.3$ E. S. U.; and radioactive-content apparatus 4, $C=8.7$ E. S. U.

Corrections to be applied to atmospheric-electric data of Volume III.—The preliminary values for the first year of Cruise IV as given in Tables 79 to 83 of Volume III may be reduced to absolute values on the finally adopted standards by the application of the following factors to the tabulated values: For λ_+ and λ_- multiply by 0.804; for n_+ and n_- multiply by 0.717; for R ("penetrating radiation") multiply by 0.889; and for Q (radium-emanation content) multiply by 0.669. It should be noted that during the recomputation of the values of Q advantage was taken of the opportunity to change slightly the grouping of data entering into certain of the means published in Volume III in order that the new values might conform in somewhat greater detail

[1] HEWLETT, C. W. Investigation of certain causes responsible for uncertainty in the measurement of atmospheric conductivity by the Gerdien conductivity apparatus. *Terr. Mag.*, vol. 19, pp. 219–233, 1914.

to such conditions as wind direction and distance from land. For corrections to the potential-gradient results of Volume III see page 209. The results during 1915 to April 1916 as published in Volume III have been included in the final Table of Results (see pp. 212–265), corrections as above indicated having been made.

Rates of air-flow.—For the ion counter and the radioactive-content apparatus it is necessary to know the volume of air passing through the apparatus.

The meter for the *ion counter* was originally provided with a calibration curve by the makers (Günther and Tegetmeyer). At the end of Cruise V it was tested in the gas laboratory of the United States Bureau of Standards prior to general cleaning and overhauling in preparation for the work of Cruise VI. After this reconditioning the meter was again tested by the Bureau of Standards, and a third time after the conclusion of Cruise VI. All tests by the Bureau of Standards gave results in practical agreement with each other and in fair agreement with the original curve of the makers, the agreement being especially good for that part of the curve used in the reduction of observations. A summary of the results of these various tests is given in Table 35, and shows the approximate constancy of the correction-factors for this meter over that part of the range most used during the period 1915–1921.

TABLE 35.—*Summary of Calibrations of Air-Flow Meter of Ion Counter No. 1.*

Indicated flow in liters per second..........	0.8	1.0	1.4	2.0	Remarks
Calibration	Correction-factor to be applied				
Günther and Tegetmeyer..................	1.08	1.10	1.12	....	
Bureau of Standards (1)..................	1.24	1.11	1.00	0.95	End of Cruise V.
Mean for cruises IV–V..............	1.16	1.10	1.06	....	
Bureau of Standards (2)..................	1.24	1.15	1.08	1.08	Beginning of Cruise VI.
Bureau of Standards (3)..................	1.19	1.12	1.05	1.04	End of Cruise VI.
Mean for Cruise VI................	1.22	1.14	1.06	1.06	

The anemometer for giving the flow of air through the collecting tube of the *radioactive-content apparatus* was calibrated in the laboratory of the Department by D. M. Wise under direction of Dr. Swann by a method described in Volume III (p. 392). Since then it has been compared several times with a similar anemometer kept in the laboratory as a standard for such comparisons. By this means it was ascertained that the correction for the anemometer used at sea had changed very little, certainly less than 5 per cent during the six years in question. Thus, the *average* uncertainty in the radioactive-content results due to changes in the correction-factor of the anemometer can not exceed several per cent.

Reduction-factors for potential-gradient observations.—Potential-gradient observations were made aboard the *Carnegie* only when the mainsail was up and the boom to port or starboard, or when the mainsail was down and the boom some 2 feet over the port crutch. The first determinations of the approximate factors for reducing volts observed on potential-gradient apparatus 2 to volts per meter in the open were made in Colon Harbor April 2, 1915, and the potential-gradient values given in Volume III for the first year's work of Cruise IV were based on the factors resulting from these observations. It was stated (p. 407), however, that "the absolute values may be liable to some change as the accumulation of other determinations renders available more reliable determination of the reduction-factors."

Additional observations for this purpose were made at Solomons Island in Chesapeake Bay at the beginning of Cruise VI, at Apia (Samoa) in July 1921, and again at

Solomons Island at the end of Cruise VI. Special observations were also made at Washington after the conclusion of Cruise VI to determine whether the reduction-factor depended in any way upon the value of the intensity of the measured field. Tests on three different days with favorable meteorological conditions showed that the reduction-factor for potential-gradient apparatus 2 as mounted on the *Carnegie* remains practically constant, at least for gradients ranging from 120 volts per meter to 480 volts per meter, which were the extreme gradients encountered during the tests. Other observations at Washington yielded important information regarding the effect of various kinds of disturbances, such as passing launches, steamboats, and smoke clouds, on the gradient observed on the *Carnegie*. Following these experiments a study and analysis were made of all the standardisation data available for the period 1915–1921.

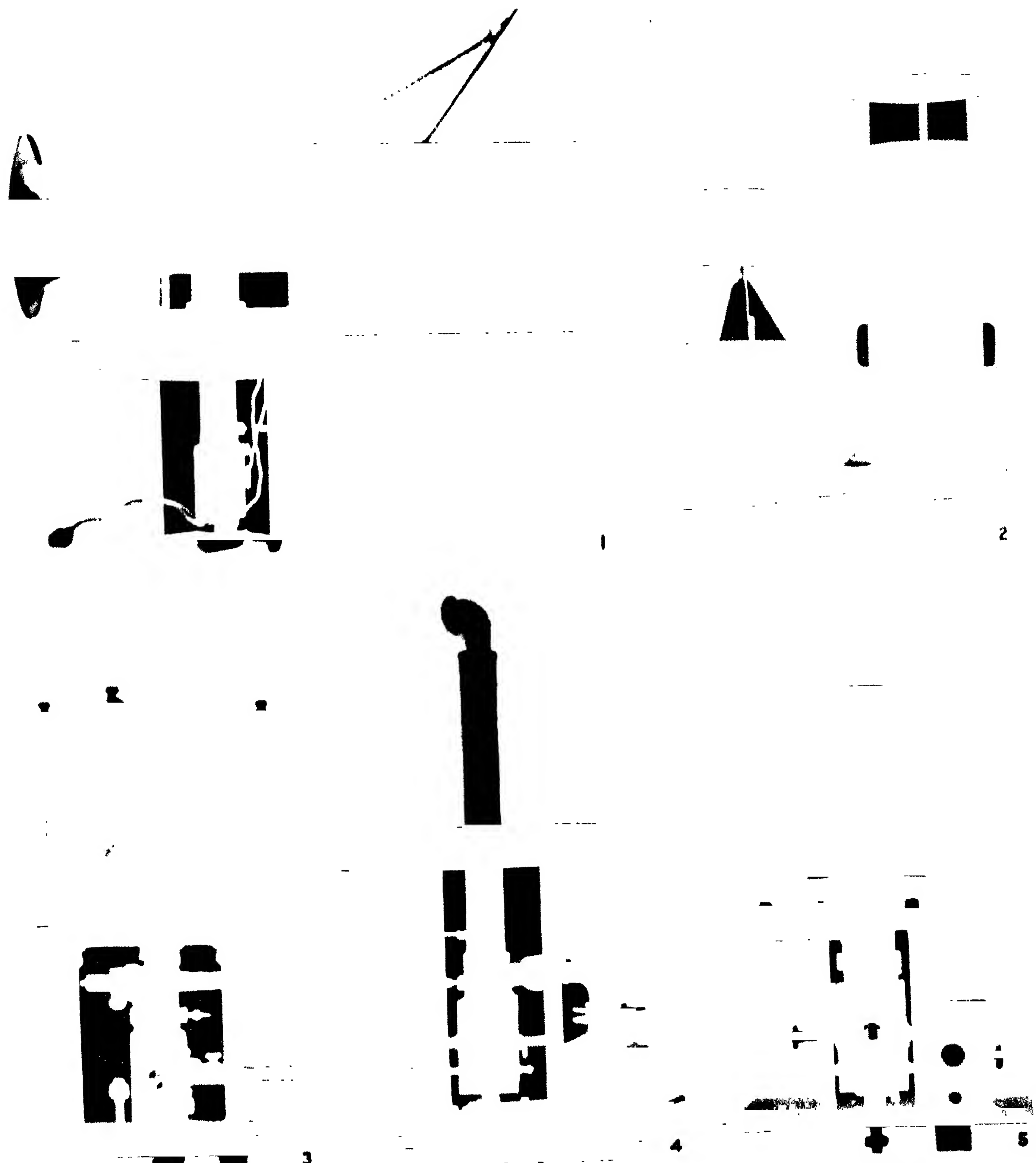
Various matters entering into the selection of a suitable site for standardization or reduction-factor observations have been discussed by Swann in Volume III (p. 382). The method which has been used for the shore observations is that described by Simpson and Wright.[1] In this method, it will be recalled, a wire some 15 or 20 meters long is suspended horizontally from two posts by suitable insulators and a collector is attached to its mid-point, at a height of 1 meter above ground. The wire is connected to an electrometer at one end and simultaneous readings are then made with this apparatus and with that on the ship.

The practice of finding a factor for reducing atmospheric potentials recorded at an observatory or on a ship to the corresponding gradient "in the open" or "over an infinite plane" assumes a close approach to simultaneity of variations at the observatory and field stations and, also for both stations, the prevalence of normal values at the time of the observations. Now, it is usually difficult to find an area of sufficient size that is practically on a level with the sea and free from trees. And it is seldom possible, when such a site is found, to bring the ship nearer to the shore station than half a mile. Various observers have shown that the progress of the potential gradient may be considerably different even at stations not more than several hundred meters apart. Sometimes this difference is manifested by the occurence of either a stationary or rising gradient at one station simultaneous with a falling gradient at the other. At other times, however, there may be almost perfect simultaneity of variations at two stations at one of which the absolute value of the gradient may be perfectly normal while at the other it may be very considerably above or below the normal value corresponding to the time of the observations.

It is obvious that under such a variety of possible combinations of phenomena the reduction-factors as deduced from all the observations as they are made from time to time will have rather widely scattering values. From the experience of the Department of Terrestrial Magnetism with potential-gradient control observations, it appears to be more desirable to make somewhat extended control observations (extending over say two or three hours) rather than more numerous short series covering only a few minutes of actual observation. The data from these longer periods are much more favorable to the detection and elimination of abnormal results caused by *temporary* local disturbances and will enable one, therefore, to arrive at a better approximation of the undisturbed reduction-factor than could otherwise be obtained.

No series of control observations have been used for computation of reduction-factors for the *Carnegie* unless the simultaneous variations are practically the same on the ship as at the shore station. (Whether or not this condition is satisfied is determined by plotting the simultaneous values on coordinate paper.) Only when this procedure is followed do the results from a number of successive series show a decided tendency toward a fixed value of the factor for a given position of sails. It is probably

[1] SIMPSON, G. C., and C. S. WRIGHT, *Proc. R. Soc. A*, vol. 85, p. 188, 1911.



ATMOSPHERIC-ELECTRIC INSTRUMENTS USED ON THE CARNEGIE DURING CRUISE VI.

1. Conductivity apparatus, side view.
2. Radioactive-content apparatus, collecting system.
3. Penetrating-radiation apparatus.
4. Ion counter, microscope removed.
5. Radioactive-content apparatus, ionizing chamber.

safe to assume that the large departures from the respective means when this selective procedure is not followed are mainly due to disturbing conditions that are not common to both stations and which tend, during their continuance, to increase or decrease the factors with respect to their normal values.

From a careful evaluation, along the above lines, of all reduction-factor observations made for the potential-gradient apparatus used aboard the *Carnegie* during the years 1915 to 1921, the following mean results have been obtained and adopted in the computation of the final values given in the Table of Results:

(a) Mainsail up and boom to port or starboard, factor designated as $A = 2.85$
(b) Mainsail down and boom 2 feet over port crutch, factor designated as $B = 3.77$

That is, with mainsail up and boom to port or starboard one volt observed on potential-gradient apparatus 2 corresponds to a gradient of 2.85 volts per meter in the open, and with mainsail down and boom 2 feet over port crutch 1 volt observed on potential-gradient apparatus 2 corresponds to a gradient of 3.77 volts per meter in the open. These values of the reduction-factors A and B are, respectively, 1.24 and 1.35 times those used in the original computations for the results as published in Volume III; the final potential-gradient values in the Table of Results have been corrected accordingly and supersede the preliminary values given in Volume III for Cruise IV to April 1916.

OCEAN ATMOSPHERIC-ELECTRIC OBSERVATIONS ON THE CARNEGIE, 1915-1921.

EXPLANATORY REMARKS FOR FINAL RESULTS, 1915-1921.

The following definitions will explain the meanings to be attached to the symbols at the heads of the tables:

P = potential gradient in volts per meter;

n_+ and n_- = respectively, the number of positive and negative ions per cubic centimeter;

λ_+ and λ_- = unipolar conductivities in E. S. U. $\times 10^{-4}$, for positive and negative ions respectively ($e = 4.8 \times 10^{-10}$ E. S. U.);

k_+ and k_- = ionic mobilities, in centimeters per second per volt per centimeter, for positive and negative ions respectively;

i = air-earth current-density in E. S. U. $\times 10^{-7}$ in the first column and in amperes $\times 10^{-16}$ per square centimeter in the second column;

R = rate of production of pairs of ions per cubic centimeter per second in a closed copper vessel of 21.6 liters capacity;

η_o = number of pairs of ions produced per second in the ionization chamber of the radioactive-content apparatus corresponding to the active material which would be deposited in an air-flow of 1 c. c. per second, the interval from the completion of the deposition to the mean time of the first determination of η in each series of observations being given in the column headed Δt; and

Q = radium-emanation content in curie $\times 10^{-18}$ per cubic centimeter. Values of Q less than 0.05 are recorded as 0.0. There is, of course, no proportionality between η_o and Q, since the latter quantity involves the shapes of the experimental decay-curve.

In view of the relatively large changes which P and λ sometimes undergo in the course of a rather short time, no values of current density are entered where the mean time of the potential-gradient observations differs by more than one-half hour from the corresponding mean time for the conductivity observations.

The values given for η_o are the results of the first determination in each series of observations; this is a departure from the method of tabulation used in Volume III, where the values designated η_o represent the number of pairs of ions produced per second three minutes after the completion of deposition.

The quantities under the heading Q have been calculated as explained on pages 393–396, Volume III. The decay curves for the sets of daily observations have been divided, in general, into groups of about 10, and the mean curve has been constructed for each group. Usually the curves resulting from observations near land show marked differences from those obtained over the ocean, and, accordingly, these have been grouped separately or analyzed individually. These mean curves, or individual curves, as the case may be, have then been used for the calculation of the corresponding values of Q. The braces under Q in the tables indicate the observations used in determining the values given.

Under the heading "Meteorological data" is given the atmospheric pressure in millimeters of mercury, corrected for zero-error of barometer, temperature, and latitude; temperature of the air in degrees centigrade; relative humidity expressed as a percentage; the true direction of the wind, given in degrees, reckoned from 0° at north through 90° at east, 180° at south and 270° at west.

The *force of the wind* is indicated according to the Beaufort scale, the figures having the following significance:

0. Calm.	5. Fresh wind.	9. Strong gale.
1. Light air.	6. Strong wind.	10. Whole gale.
2. Light breeze.	7. Moderate gale.	11. Storm.
3. Gentle breeze.	8. Fresh gale.	12. Hurricane.
4. Moderate breeze.		

The estimated velocity of the wind in statute miles per hour may be obtained approximately by multiplying the force by 6, except for forces 11 and 12, where the estimated velocities are 75 and 90 statute miles per hour, respectively.

The *character of clouds* indicated is based on the international system of classification; the *amount of cloudiness* is given on a scale of 10. The abbreviations and descriptions of the various forms, according to the international classification of 1905 as furnished by the United States Weather Bureau, are as follows:

Ci (cirrus).—Detached clouds of delicate and fibrous appearance, often showing a feather-like structure, generally of a whitish color.

Ci-St (cirro-stratus).—A thin, whitish sheet of clouds.

Ci-Cu (cirro-cumulus, mackerel sky).—Small globular masses or white flakes without shadows, or showing very slight shadows, arranged in groups and often in lines.

A-St (alto-stratus).—A thick sheet of gray or bluish color, sometimes forming a compact mass of dark-gray color and fibrous structure.

A-Cu (alto-cumulus).—Largish globular masses, white or grayish, partly shaded, arranged in groups or lines, and often so closely packed that their edges appear confused.

St-Cu (strato-cumulus).—Large globular masses or rolls of dark cloud often covering the whole sky, especially in winter.

Cu (cumulus, woolpack clouds).—Thick clouds of which the upper surface is dome-shaped and exhibits protuberances while the base is horizontal.

Fr-Cu (fracto-cumulus).—A broken cloud resembling cumulus in which the detached portions undergo continual change in strong winds.

Cu-Nb (cumulo-nimbus, thunder cloud, shower cloud).—Heavy masses of cloud rising in the form of mountains, turrets, or anvils, generally surmounted by a sheet or screen of fibrous appearance (false cirrus), and having at its base a mass of cloud similar to nimbus.

Nb (nimbus, rain clouds).—A thick layer of dark clouds without shape and with ragged edges.

St (stratus).—A uniform layer of cloud resembling a fog but not resting on the ground.

Fr-St (fracto-stratus).—Stratus cloud broken up into irregular shreds in a wind or by summits of mountains.

The state of the weather is given in accordance with the following conventions which are in general use:

b. Clear, blue sky.	*m.* Misty.	*t.* Thunder.
c. Clouds.	*o.* Overcast.	*u.* Ugly appearances, threatening weather.
d. Drizzling or light rain.	*p.* Passing showers.	*v.* Variable weather.
f. Fog or foggy weather.	*q.* Squally.	*w.* Wet or heavy dew.
g. Gloomy, dark, stormy.	*r.* Rain.	*z.* Hazy weather.
h. Hail.	*s.* Snow.	
l. Lightning.		

During cruises IV and V the geographical position given at the commencement of a 24-hour series applies to the mean time of the entire series, while for Cruise VI two positions are given, the first applying to the mean time of the series from the beginning up to 18^h and the second applying to the mean time of the series from 18^h to the end.

The results of some studies by Louis A. Bauer and S. J. Mauchly of the material given in the Table of Results will be found on pages 359 to 424 of this volume.

FINAL RESULTS OF OCEAN ATMOSPHERIC-ELECTRIC OBSERVATIONS ON THE CARNEGIE, 1915–1921.

CRUISE IV, ATLANTIC OCEAN, 1915.

Lat.	Long. E. of Gr.	Date	Potential gradient L.M.T.	Potential gradient P	Ionic content L.M.T.	n_+	n_-	Conductivity λ_+	Conductivity λ_-	Ionic mobility k_+	Ionic mobility k_-	Current-density, i (ESU × 10^{-7})	Current-density, i ($\times 10^{-16}$ amp/cm²)	Penetrating radiation L.M.T.	R (ions/cc/s)	Radioactive content L.M.T.	Ionization q_0 (ions/cc/s)	AT	Q	Meteorological data L.M.T.	Pressure	Temp. Cent.	[illegible]	Wind True dir.	Wind [illegible]	Clouds Kind	Clouds Am't	Weather
°	°	1915	h	(V/m)	h	(ions/cc)		(ESU×10^{-4})		(cm/s / V/cm)				h		h		m	°	h	mm	°		°				
Brooklyn																												
31.1 N	288.3	Mar 12	9.4	187	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	8.0	762	10.0	76	204	4	...	...	[illegible]
28.2 N	286.6	13	9.0	241	17.3	180	...	...	...	...	...	...	...	...	...	...	...	...	...	8.0	767	17.5	55	258	4	...	...	[illegible]
26.5 N	289.2	14	...	...	15.6	288	280	...	...	...	...	...	...	...	...	...	...	...	...	16.0	762	18.4	77	131	1	...	...	[illegible]
24.0 N	289.3	15	8.8	117	13.0	486	430	1.10	0.89	1.87	1.34	...	...	...	...	...	...	...	...	12.0	760	21.5	87	88	4	...	...	[illegible]
23.9 N	289.8	16	13.0	[illegible]	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	14.0	762	24.4	[illegible]	254	2	...	...	[illegible]
22.2 N	288.0	17	15.6	107	12.4	340	300	0.81	0.87	1.35	1.70	...	...	...	...	...	...	...	...	12.0	762	25.5	[illegible]	105	4	...	...	[illegible]
20.8 N	288.3	18	10.3	140	10.1	288	235	0.38	0.41	1.42	0.90	4.3	1.4	17.7	3.42	...	...	...	...	10.5	763	24.8	[illegible]	245	3	...	...	[illegible]
18.3 N	286.8	19[1]	11.4	125	11.4	288	288	0.94	0.91	1.08	1.05	7.7	2.8	...	...	...	...	...	...	12.0	762	26.5	85	128	4	...	...	[illegible]
16.8 N	289.5	20	12.2	160	11.9	380	361	1.11	0.87	1.48	1.67	7.2	2.4	...	...	...	...	...	...	12.0	762	25.5	[illegible]	124	3	...	●	[illegible]
15.4 N	287.5	21	9.3	143	9.2	488	411	0.88	0.43	0.96	0.74	4.8	1.6	18.9	2.88	...	...	...	...	9.0	760	25.4	[illegible]	91	4	...	...	[illegible]
13.6 N	284.8	22	9.7	135	9.3	385	385	0.77	0.36	1.85	0.65	3.9	1.3	10.7	3.32	...	...	...	...	8.6	760	29.5	76	79	4	...	...	[illegible]
13.2 N	284.3	23	16.7	128	16.6	344	304	0.36	0.36	1.08	0.95	3.0	1.0	...	...	...	...	...	...	17.0	757	27.3	[illegible]	70	3	...	...	[illegible]
13.9 N	283.8	24	23.9	130	23.9	384	182	...	0.37	...	1.70	...	...	20.5	4.88	...	...	...	...	20.5	760	26.5	[illegible]	3	3	...	...	[illegible]
12.6 N	283.3	25	5.1	125	...	...	...	...	...	...	...	...	...	6.4	2.47	...	...	...	...	5.0	760	26.0	84	3	3	...	...	[illegible]
11.3 N	282.7	26	10.0	185	10.3	185	187	0.20	0.31	1.30	1.09	2.1	0.7	11.6	2.76	...	...	...	...	10.4	760	29.5	72	300	3	...	...	[illegible]
9.4 N	280.1	[illegible]	10.6	182	10.6	281	285	0.41	0.35	0.90	0.84	3.3	1.1	11.4	2.91	...	...	...	...	11.0	761	29.8	71	25	5	...	...	[illegible]
Cristobal, Canal Zone																												

CRUISE IV, PACIFIC OCEAN, 1915.

Lat.	Long. E. of Gr.	Date	Potential gradient L.M.T.	Potential gradient P	Ionic content L.M.T.	n_+	n_-	Conductivity λ_+	Conductivity λ_-	Ionic mobility k_+	Ionic mobility k_-	Current-density, i (ESU × 10^{-7})	Current-density, i ($\times 10^{-16}$ amp/cm²)	Penetrating radiation L.M.T.	R	Radioactive content L.M.T.	Ionization q_0	AT	Q	Meteorological data L.M.T.	Pressure	Temp. Cent.	[illegible]	Wind True dir.	Wind [illegible]	Clouds Kind	Clouds Am't	Weather
°	°	1915	h	[illegible]	h	[illegible]		[illegible]		(cm/s / V/cm)		[illegible]		h	[illegible]	h	[illegible]	m	°	h	mm	°		°				
Balboa, Canal Zone																												
6.6 N	[illegible]	Apr [illegible]	9.6	[illegible]	9.7	[illegible]	[illegible]	0.78	0.78	1.20	0.97	6.2	2.1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	10.0	[illegible]	28.5	85	[illegible]	3			[illegible]
5.7 N	[illegible]	[illegible]	9.5	[illegible]	9.6	[illegible]	[illegible]	0.80	0.79	1.35	1.32	10.1	2.4	11.4	3.06	10.1	3.25	5.2	5	9.9	[illegible]	28.5	71	[illegible]	0		●	[illegible]
3.8 N	[illegible]	[illegible]	14.0	[illegible]	14.1	[illegible]	[illegible]	0.76	0.67	1.27	1.00	8.6	2.9	15.2	2.89	[illegible]	2.65	5	[illegible]	14.0	[illegible]	28.7	76	66	3			[illegible]
2.7 N	[illegible]	[illegible]	9.6	[illegible]	9.5	[illegible]	[illegible]	[illegible]	[illegible]	1.20	1.48	7.6	2.6	10.9	3.10	[illegible]	[illegible]	[illegible]	[illegible]	10.1	[illegible]	28.6	73	66	2			[illegible]
2.2 N	[illegible]	[illegible]	9.6	[illegible]	9.7	[illegible]	[illegible]	[illegible]	[illegible]	1.20	1.20	[illegible]	2.7	12.2	2.80	[illegible]	2.12	5	[illegible]	10.2	[illegible]	28.0	[illegible]	[illegible]	4			[illegible]
3.4 N	[illegible]	[illegible]	9.5	[illegible]	9.6	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.25	[illegible]	3.1	10.5	3.08	[illegible]	1.08	7	[illegible]	9.9	[illegible]	28.6	73	[illegible]	3			[illegible]
2.2 N	[illegible]	[illegible]	10.0	[illegible]	10.0	[illegible]	[illegible]	0.72	[illegible]	1.20	2.12	[illegible]	2.0	11.9	3.00	[illegible]	1.25	5	[illegible]	10.4	[illegible]	28.2	72	[illegible]	2			[illegible]
2.1 N	[illegible]	[illegible]	15.2	[illegible]	15.4	[illegible]	[illegible]	[illegible]	[illegible]	0.25	0.77	[illegible]	1.7	17.3	3.07	17	1.35	5	1.7	17.5	[illegible]	27.9	75	[illegible]	2			[illegible]
2.0 N	[illegible]	[illegible]	22.2	[illegible]	22.3	[illegible]	[illegible]	[illegible]	[illegible]	0.25	2.00	[illegible]	2.7	[illegible]	2.57	[illegible]	1.11	11	[illegible]	22.5	[illegible]	27.5	79	[illegible]	3			[illegible]
2.0 N	[illegible]	[illegible]	4.6	[illegible]	6.5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2.18	[illegible]	3.4	5	3.20	[illegible]	[illegible]	[illegible]	[illegible]	5.0	[illegible]	27.0	[illegible]	[illegible]	3			[illegible]
3.9 N	[illegible]	[illegible]	9.5	[illegible]	9.5	[illegible]	[illegible]	1.27	[illegible]	1.97	[illegible]	[illegible]	0.7	[illegible]	3.65	[illegible]	[illegible]	5	[illegible]	10.0	[illegible]	28.3	[illegible]	251	3			[illegible]
3.5 N	[illegible]	[illegible]	9.5	[illegible]	9.5	[illegible]	[illegible]	[illegible]	[illegible]	1.38	1.38	[illegible]	4.4	[illegible]	3.18	[illegible]	[illegible]	[illegible]	[illegible]	9.9	[illegible]	28.5	[illegible]	[illegible]	3			[illegible]
4.7 N	[illegible]	[illegible]	9.7	[illegible]	9.6	[illegible]	[illegible]	1.85	1.35	1.20	1.55	[illegible]	3.7	[illegible]	3.10	[illegible]	[illegible]	4	[illegible]	10.2	[illegible]	28.7	79	[illegible]	1		●	[illegible]
4.5 N	[illegible]	[illegible]	9.7	[illegible]	9.7	[illegible]	[illegible]	1.47	1.35	1.38	1.50	[illegible]	4.2	[illegible]	3.10	[illegible]	[illegible]	5	[illegible]	10.2	[illegible]	28.0	76	123	2			[illegible]
3.8 N	[illegible]	[illegible]	9.7	[illegible]	9.7	[illegible]	[illegible]	1.27	0.77	1.28	0.90	[illegible]	3.0	[illegible]	3.46	[illegible]	[illegible]	3	[illegible]	10.3	[illegible]	28.2	77	[illegible]	0			[illegible]
4.3 N	[illegible]	[illegible]	16.7	[illegible]	21.6	[illegible]	[illegible]	1.87	1.45	1.40	1.25	[illegible]	7.6	[illegible]	3.28	[illegible]	[illegible]	[illegible]	[illegible]	12.0	[illegible]	28.3	76	[illegible]	1			[illegible]

[illegible] during previous night. [2] Rain storm approaching; quite cloudy; gloomy during second half. [3] In [illegible] Passage. [4] At anchor in [illegible] Bay. Heavy rain storm previous night. [5] Squall coming up; heavy rain storm

[1] Following this set P increased to over 1500 v/m on account of approaching squalls. [2] This value is a negative potential gradient. [3] Results questioned on account of large leak. [4] Squall approaching. [5] New can in place, with air of humidity. [6] Old can now in place again. [7] Squalls coming up from two directions. [8] Raining quite steadily.

FINAL RESULTS OF OCEAN ATMOSPHERIC-ELECTRIC OBSERVATIONS ON THE CARNEGIE, 1915-1921—*Continued.*

CRUISE IV, PACIFIC OCEAN, 1915—*Continued.*

Lat.	Long. E. of Gr.	Date	Potential gradient L.M.T.	Potential gradient P	L.M.T.	Ionic content n_+	Ionic content n_-	Conductivity λ_+	Conductivity λ_-	Ionic mobility k_+	Ionic mobility k_-	Current-density, i	Current-density, i	Penetrating radiation L.M.T.	Penetrating radiation	Radioactive content L.M.T.	Radioactive content Ionization	Radioactive content ΔT	Q	L.M.T.	Pressure	Temp. Cent.	Rel. hum.	Wind True dir.	Wind	Clouds Kind	Clouds Am't	Weather
°	°	1915	h	(v/m)	h	(ions/cm³)	(ions/cm³)	(ESU)×10⁻⁴	(ESU)×10⁻⁴	(cm/s / v/cm)	(cm/s / v/cm)	(ESU)×10⁻⁷	(amp×10⁻¹⁶/cm²)	h	(ions/cm³ / s)	h	(ions/cm³ / s)	m		h	mm	°	p.ct.	°				
[illegible]	[illegible]	Jul / Aug	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

[illegible] per cubic centimeter. † Not used in the computation of Q, [illegible]. [illegible] † Very poor, [illegible]. [illegible] by rain. [illegible] • Heavy gale, high sea, shipping water.

[illegible]

FINAL RESULTS OF OCEAN ATMOSPHERIC-ELECTRIC OBSERVATIONS ON THE CARNEGIE, 1915-1921—*Continued.*

CRUISE IV, PACIFIC OCEAN, 1915—*Continued.*

Lat.	Long. E. of Gr.	Date	Potential gradient L.M.T.	Potential gradient F	L.M.T.	Ionic content n_+	Ionic content n_-	Conductivity λ_+	Conductivity λ_-	Ionic mobility k_+	Ionic mobility k_-	Current-density, i	Current-density, i	Penetrating radiation L.M.T.	Penetrating radiation Q	Radioactive content L.M.T.	Ionization q_0	ΔT	Q*	Meteorological data L.M.T.	Press.	Temp.	Rel. hum.	Wind True dir.	Wind Force	Clouds Kind	Clouds Am't	Weather
°	°	1915	h	$\left(\frac{v}{m}\right)$	h	$\left(\frac{ions}{cc}\right)$		(ESU×10⁻⁴)		$\left(\frac{cm/s}{v/cm}\right)$		(ESU× 10⁻⁷)	$\left(\frac{A\times10^{-16}}{cm^2}\right)$	h	$\left(\frac{ions/cc}{s}\right)$	h	$\left(\frac{ions/cc}{s}\right)$	m		h	mm	°	p.ct.	°				
27.3 N	160.3	Sep 4	[illegible]	[illegible]	[illegible]	[illegible]								[illegible]	[illegible]					[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Cu	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

*Curie×10⁻¹² per cubic centimeter.

FINAL RESULTS OF OCEAN ATMOSPHERIC-ELECTRIC OBSERVATIONS ON THE CARNEGIE, 1915–1921—*Continued.*

CRUISE IV, PACIFIC OCEAN, 1915—*Continued.*

Lat.	Long. E. of Gr.	Date	Potential gradient L. M. T.	Potential gradient P	Ionic content L. M. T.	Ionic content n_+	Ionic content n_-	Conductivity λ_+	Conductivity λ_-	Ionic mobility k_+	Ionic mobility k_-	Current-density, i	Current-density, i	Penetrating radiation L. M. T.	Penetrating radiation B	Radioactive content, Ionization L. M. T.	Radioactive content, Ionization q_0	Radioactive content ΔT	Q	Meteorological data L. M. T.	Pressure	Temp. Cent.	Rel. hum.	Wind True dir.	Wind Force	Clouds Kind	Clouds Am't	Weather
°	°	*1915*	h	(v/m)	h	(ions/cc)		($ESU \times 10^{-4}$)		(cm/s / v/cm)		($ESU \times 10^{-7}$)	($a \times 10^{-16}$/cm²)	h	(ions/cc / s)	h	(ions/cc / s)	m	*	h	mm	°	p. ct.	°				
21.9 S	157.2	Oct 16	12.6	130	12.0	520	...	...	...	...	...	...	...	12.0	2.83	...	...	...		12.4	762	26.9	60	...	0	...	0	b
		16	13.6	118	13.0	504	...	...	...	...	...	...	...	13.0	2.84	...	...	...		13.4	761	24.4	70	133	1	...	0	b
		16	14.6	120	14.0	523	...	...	...	...	...	...	...	14.0	2.91	...	...	...		14.4	760	23.3	74	178	2	...	0	b
		16	15.6	125	15.0	506	...	...	...	...	...	...	...	15.0	2.83	...	...	...		15.4	759	23.5	72	144	2	...	0	b
		16	16.6	122	16.0	578	...	...	...	...	...	...	...	16.0	2.75	...	...	...		16.4	759	24.0	66	144	1	...	0	b
		16	17.6	124	17.0	590	...	...	...	...	...	...	...	17.0	2.86	...	...	...		17.4	760	24.5	62	144	1	...	0	b
		16	18.6	120	18.0	634	...	...	...	...	...	...	...	17.9	2.85	...	...	...		18.4	761	23.5	74	...	0	...	0	b
		16	19.6	114	19.0	565	...	...	...	...	...	...	...	19.0	2.85	...	...	...		19.4	761	23.1	66	...	0	...	0	b
		16	20.6	109	20.0	572	...	...	...	...	...	...	...	20.0	2.86	...	...	...		20.4	761	23.0	65	133	1	...	0	b
		16	21.6	125	21.0	631	...	...	...	...	...	...	...	21 0	2.92	...	...	...		21.4	762	22.8	59	133	1	...	0	b
		16	22.6	148	22.0	588	...	...	...	...	...	...	...	22.0	2.94	...	...	...		22.4	762	22.7	63	133	1	...	0	b
		16	23.6	149	23.0	565	...	...	...	...	...	...	...	23.0	2.80	...	...	...		23.4	761	22.6	62	133	1	...	0	b
		17	0.6	172	0.0	583	...	...	...	...	...	...	...	0.0	2.83	...	...	...		0.4	761	22.6	66	122	1	...	0	b
		17	1.6	163	1.0	583	...	...	...	...	...	...	...	1.0	2.68	...	...	...		1.4	761	22.9	65	99	1	...	0	b
		17	2.6	158	1.9	578	...	...	...	...	...	...	...	2.0	3.24	...	...	...		2.4	760	22.7	68	99	1	...	0	b
		17	3.6	150	2.9	610	...	...	...	...	...	...	...	2.9	3.50	...	...	...		3.4	761	22.6	69	99	1	...	0	b
		17	4.6	146	3.9	595	...	...	...	...	...	...	...	3.9	3.75	...	...	...		4.4	761	22.7	65	99	1	Nb	2	bc
		17	5.6	178	4.9	581	...	...	...	...	...	...	...	4.9	3.60	...	...	...		5.4	761	22.8	66	99	1	Cu-Nb	6	bc
		17	6.6	106	6.0	607	...	...	...	...	...	...	...	6.0	2.84	...	...	...		6.4	761	24.4	64	99	2	Ci-Cu	1	bc
		17	7.6	102	7.0	628	...	...	...	...	...	...	...	7.0	2.98	...	...	...		7.4	762	24.0	66	99	2	Cu	6	bc
23.4 S	157.1	18	9.4	190	9.3	383	328	0.88	0.74	1.60	1.57	10.3	3.4	11.2	2.74	10.2	†3.70	3.1		9.7	762	24.2	77	99	4	...	0	b
24.1 S	156.8	19	8.7	174	8.7	302	229	0.56	0.47	1.29	1.43	6.0	2.0	8.6	2.75	9.2	5.04	3.5		9.0	765	22.6	76	122	3	Cu-Nb	9	cqr
26.0 S	155.6	20	9.0	160	9.0	333	352	0.64	0.59	1.34	1.17	6.6	2.2	8.0	2.83	9.5	2.43	5.0		9.2	765	22.1	60	122	4	Cu	3	bc
27.8 S	154.6	21	9.3	105	9.2	494	457	1.05	0.92	1.48	1.40	6.9	2.3	8.2	2.85	9.8	3.38	4.5		9.6	767	22.0	61	122	3	...	...	bc
29.9 S	155.4	22	9.5	137	9.2	784	658	1.75	1.58	1.55	1.67	15.2	5.1	11.2	2.89	10.0	0.51	6.6		9.8	767	21.6	63	44	4	...	...	bc
32.8 S	157.3	23	9.4	118	9.4	797	708	1.56	1.53	1.36	1.50	12.2	4.1	10.8	2.86	10.0	0.21	9.5		9.8	764	20.7	73	33	6	Cu-Nb	6	bc
35.6 S	158.4	24[1]	10.5	137	10.6	515	451	0.86	0.66	1.16	1.02	6.9	2.3	12.0	2.81	10.1	15.66	5.4		10.9	754	18.0	87	237	1	Cu	2	bc
36.4 S	160.0	25	9.1	46	9.0	868	574	1.22	0.90	0.98	1.09	3.3	1.1	...	...	...	...	...		9.4	750	14.6	95	...	0	Cu-Nb	10	oq
		25	9.2	[2]−86	...	...	...	...	...	...	...	...	...	...	...	...	...	...		...	...	...	...	...	...	...	...	...
		25	10.4	124	10.6	978	620	0.90	0.92	0.64	1.03	7.5	2.5	11.8	3.13	10.9	11.07	3.5		10.7	752	16.2	88	...	0	Cu-Nb	10	o
37.1 S	161.3	26	9.3	130	9.2	850	659	1.37	1.29	1.12	1.36	11.5	3.8	10.6	3.00	9.8	2.80	4.5		9.5	753	14.5	80	216	4	Cu	2	bc
38.4 S	162.0	27	8.5	133	8.0	753	...	...	...	...	...	...	...	8.0	3.43	...	...	...		8.3	754	14.7	66	272	1	Cu	1	bc
		27	9.5	161	9.2	746	621	1.37	1.30	1.28	1.45	14.3	4.8	9.2	3.32	...	...	...		9.3	754	15.5	73	272	1	Cu	2	bc
		27	10.5	128	10.0	753	...	...	...	...	...	...	...	9.9	2.73	10.0	†1.05	4.8		10.3	754	15.8	68	272	1	Ci-Cu	2	bc
		27	11.5	140	11.0	746	...	...	...	...	...	...	...	10.9	3.25	...	...	...		11.3	753	17.5	62	272	1	Ci-Cu	2	bc
		27	12.5	151	11.9	778	...	...	...	...	...	...	...	11.9	3.24	...	...	...		12.3	753	17.0	61	272	1	Ci-Cu	7	bc
		27	13.5	144	13.0	824	...	...	...	...	...	...	...	12.9	3.30	...	...	...		13.3	753	18.7	61	261	1	Ci-Cu	3	bc
		27	14.5	121	14.0	792	...	...	...	...	...	...	...	14.0	3.25	...	...	...		14.3	753	19.0	55	272	1	Ci-Cu	3	bc
		27	15.5	133	15.0	726	...	...	...	...	...	...	...	15.0	3.20	...	...	...	3.6	15.3	753	18.5	58	328	1	Ci-Cu	4	bc
		27	16.5	122	15.9	759	...	...	...	...	...	...	...	15.9	3.24	...	...	...		16.3	753	16.0	65	328	1	Ci-Cu, Nb	7	bc
		27	[3]17.5	153	17.0	713	...	...	...	...	...	...	...	17.0	3.24	...	...	...		17.3	752	15.4	73	328	3	Cu-Nb	10	ocq
		27	...	...	[3]17.9	778	...	...	...	...	...	...	...	17.8	3.20	...	...	...		18.3	752	15.0	82	328	4	Cu-Nb	10	qr

*Curie×10⁻¹⁸ per cubic centimeter. †Not used in the computation of Q, irregular. [1] Observations delayed by rain. [2] Squalls all around during previous set; rain squall interrupted this set, giving a negative potential gradient. [3] Heavy squalls all around; observations interrupted by rain.

39.3 S	162.1	Oct	28	10.4	[1]75	10.4	696	577	0.85	0.64	0.85	0.77	3.7	1.2	12.0	3.12	11.5	6.13	4.5		11.9	753	15.8	70	.....	0	Cu	3	bc
41.4 S	162.6		29	[2]8.4	0	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....		8.0	754	14.7	88	352	6	.....	.....	oo
			29	[2]8.4	+31	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....		.....	.....	.....	.....	.....	.....	.....	.....	.....
			29	[2]8.4	+ 6	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....		.....	.....	.....	.....	.....	.....	.....	.....	.....
			29	[2]8.4	+18	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....		.....	.....	.....	.....	.....	.....	.....	.....	.....
			29	[2]8.5	0	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....		.....	.....	.....	.....	.....	.....	.....	.....	.....
			29	[2]8.5	+ 6	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....		.....	.....	.....	.....	.....	.....	.....	.....	.....
			29	[2]8.5	−12	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....		.....	.....	.....	.....	.....	.....	.....	.....	.....
			29	[2]8.5	−50	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....		.....	.....	.....	.....	.....	.....	.....	.....	.....
			29	[2]8.5	−38	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....		.....	.....	.....	.....	.....	.....	.....	.....	.....
41.8 S	162.7		29	10.8	146	10.9	700	707	1.48	1.31	1.47	1.28	13.6	4.5	11.7	3.04	11.3	16.19	5.6		11.1	753	13.8	86	285	6	.....	10	or
44.5 S	164.0		30	8.4	171	8.5	753	601	1.76	1.29	1.63	1.49	17.4	5.8	9.5	2.98	8.9	†0.55	8.0		8.8	745	11.8	80	264	6	Cu	4	bc
46.6 S	187.7		31[3]	9.9	80	10.0	753	648	0.91	0.79	0.84	0.85	4.5	1.5	11.6	3.07	10.4	0.98	6.7		10.2	749	12.0	78	287	6	.....	.....	o
46.4 S	170.2	Nov	1	9.2	63	9.3	664	500	1.56	1.34	1.63	1.58	6.1	2.0	10.7	3.18	9.8	0.47	10.0		9.6	750	10.2	87	130	3	Cu-Nb	10	o
44.9 S	172.6		2	9.4	165	9.2	1021	817	1.32	1.16	0.90	0.98	13.6	4.5	11.5	3.39	9.9	6.49	7.6		9.8	754	10.3	81	209	3	Cu	6	bc
Lyttelton																													

CRUISE IV, SOUTHERN OCEAN, 1915–1916.

°	°	1916		h	$\left(\frac{V}{m}\right)$	h	$\left(\frac{ions}{cc}\right)$		$(ESU\times10^{-4})$		$\left(\frac{cm/s}{V/cm}\right)$		$(ESU\times10^{-7})$	$\left(\frac{a\times10^{-18}}{cm^2}\right)$	h	$\left(\frac{ions/cc}{s}\right)$	h	$\left(\frac{ions/cc}{s}\right)$	m	°	h	mm	°	p.d.	°				
Lyttelton																													
46.2 S	174.7	Dec	7	11.7	249	11.7	.....	.....	0.69	0.47	.....	.....	9.6	3.2	.....	.....	.....	.....	.....		12.0	749	12.6	91	40	2	Cu-Nb	10	o
47.7 S	176.3		8	10.2	[4]76	10.3	.....	403	.....	0.59	.....	1.02	.....	.....	11.6	3.33	.....	.....	.....		10.8	743	10.0	92	232	6	Cu-Nb	10	or
49.1 S	178.5		9	10.7	[5]74	11.9	591	427	1.09	0.91	1.28	1.48	.....	.....	13.6	3.33	11.2	1.88	3.6		10.8	748	9.0	94	211	7	Cu-Nb	10	oru
50.1 S	181.4		9[6]	10.7	122	10.1	699	584	1.39	1.15	1.38	1.37	.....	.....	11.9	3.26	11.6	0.88	4.2		11.0	751	8.5	88	213	6	Cu-Nb	9	or
53.1 S	186.6		11	9.4	115	9.5	786	677	1.43	1.34	1.26	1.38	10.6	3.5	10.2	3.65	10.1	0.43	4.5		9.7	752	9.1	88	213	6	Cu-Nb	9	orm
54.4 S	191.6		13	9.4	155	9.4	676	535	1.36	1.09	1.40	1.42	12.7	4.2	10.8	3.83	10.1	†[7]0.09	14.4		9.7	746	6.8	78	214	5	Cu-Nb	8	o
			13	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	11.0	†[8]0.09	15.9		.....	.....	.....	.....	.....	.....	Cu-Nb	7	bo
54.7 S	192.1		13	13.8	94	13.3	596	.....	.....	.....	.....	.....	.....	.....	13.2	3.85	.....	.....	.....		13.5	745	7.5	66	214	6	Ci-Cu	7	bc
			13	14.7	126	14.3	687	.....	.....	.....	.....	.....	.....	.....	14.2	3.35	.....	.....	.....		14.5	745	7.5	66	214	6	Ci-Cu	6	bo
			13	15.7	118	15.3	669	.....	.....	.....	.....	.....	.....	.....	15.2	3.43	.....	.....	.....		15.5	745	7.5	66	214	6	A-Ci, Cu	5	bo
			13	16.7	92	16.2	571	.....	.....	.....	.....	.....	.....	.....	16.2	3.31	.....	.....	.....		16.5	745	7.2	68	226	5	Ci-Cu	4	bcq
			13	17.7	109	17.2	584	.....	.....	.....	.....	.....	.....	.....	17.2	3.50	.....	.....	.....		17.5	745	6.8	72	226	5	Ci-Cu, Nb	9	cqr
			13	18.9	117	18.0	590	.....	.....	.....	.....	.....	.....	.....	18.0	4.02	.....	.....	.....		18.5	745	.....	.....	226	5	.....	.....	q
			13	19.7	102	19.2	606	.....	.....	.....	.....	.....	.....	.....	19.1	3.63	.....	.....	.....		19.5	745	6.0	80	226	4	Ci-Cu, Nb	8	cq
			13	20.7	93	20.2	617	.....	.....	.....	.....	.....	.....	.....	20.2	3.49	.....	.....	.....		20.5	746	6.0	76	226	4	Cu-Nb	6	bcq
			13	21.8	149	21.2	556	.....	.....	.....	.....	.....	.....	.....	21.3	3.69	.....	.....	.....		21.5	746	6.1	77	226	4	Cu-Nb	6	bcq
56.0 S	197.6		15	8.8	159	8.9	644	557	1.09	1.06	1.18	1.33	11.4	3.8	10.3	3.76	9.4	0.71	3.4		9.2	752	5.6	73	.....	0	Cu-Nb	8	o
60.4 S	208.7		18	9.9	289	9.8	295	197	0.47	0.33	1.11	1.17	7.7	2.6	12.0	3.85	.....	.....	.....		10.4	720	1.5	73	26	10	Cu-Nb	10	ofm
60.5 S	220.2		20	10.4	131	10.4	464	383	0.95	0.84	1.42	1.52	7.8	2.6	12.4	3.81	.....	.....	.....		10.9	721	1.4	88	346	5	Cu-Nb	10	os
59.7 S	231.7		22	9.1	248	9.8	509	356	1.03	0.64	1.20	1.25	.....	.....	.....	.....	.....	.....	.....		9.8	738	4.0	88	335	3	Cu-Nb	10	o
			22	10.0	241	10.5	561	.....	.....	.....	.....	.....	.....	.....	10.5	3.48	10.8	0.51	4.3		10.8	738	4.0	91	335	3	Cu-Nb	10	o
			22	10.9	120	11.4	577	.....	.....	.....	.....	.....	.....	.....	11.4	3.58	.....	.....	.....		.....	.....	.....	.....	.....	.....	Cu-Nb	10	ot
59.7 S	232.8		22	15.0	166	15.4	523	.....	.....	.....	.....	.....	.....	.....	15.4	3.63	.....	.....	.....		.....	.....	.....	.....	.....	.....	Ci	.....	bcf
			22	15.8	150	16.2	458	.....	.....	.....	.....	.....	.....	.....	16.2	3.60	.....	.....	.....		15.8	739	5.7	90	9	2	Ci, Nb	4-9	bo
			22	16.8	146	17.2	542	.....	.....	.....	.....	.....	.....	.....	17.2	3.73	.....	.....	.....		16.8	739	5.3	92	346	2	Ci, Cu	9	o
			22	17.8	149	18.1	418	.....	.....	.....	.....	.....	.....	.....	18.1	3.58	.....	.....	.....		17.8	739	4.7	95	358	2	Ci, Cu	10	o
			22	18.8	181	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....		18.8	740	4.5	95	358	2	Ci, Cu	10	of
			22	19.9	186	20.3	342	.....	.....	.....	.....	.....	.....	.....	20.3	3.93	.....	.....	.....		19.8	740	4.4	96	30	3	Ci, Cu	10	fr
			22	20.8	226	21.2	298	.....	.....	.....	.....	.....	.....	.....	21.2	3.64	.....	.....	.....		20.8	741	4.2	97	30	3	Ci, Cu	9	fw
			22	21.8	167	22.3	333	.....	.....	.....	.....	.....	.....	.....	22.3	3.51	.....	.....	.....		21.8	741	4.5	97	30	2	Ci-St, Cu	9	cf
60.7 S	236.4		23	11.2	207	11.1	434	318	0.84	0.62	1.35	1.36	10.1	3.4	12.5	3.30	12.0	0.28	9.5		11.7	740	5.7	89	33	5	Cu-Nb	10	o
59.2 S	241.6		25	9.8	188	9.9	403	350	1.50	.....	2.58	.....	.....	.....	11.1	3.49	10.4	0.47	5.3		10.2	740	4.2	87	234	6	Cu-Nb	10	o

* Curie × 10⁻¹⁸ per cubic centimeter. †Not used in the computation of Q, irregular. [1] Heavy thunder cloud coming up. [2] Readings taken every 30 seconds as heavy rain came on. [3] Passing through Foveaux Strait, New Zealand.
[4] Sprinkling during observations; rain at end. [5] Spray flying; rain interrupted. [6] Crossed 180th meridian, hence date December 9 repeated. [7] 2,700 volts on collecting foil. [8] 950 volts on collecting foil.

FINAL RESULTS OF OCEAN ATMOSPHERIC-ELECTRIC OBSERVATIONS ON THE CARNEGIE, 1915–1921—*Continued.*

CRUISE IV, SOUTHERN OCEAN, 1915–1916—*Continued.*

Lat.	Long. E. of Gr.	Date		Potential gradient L.M.T.	Potential gradient P	L.M.T.	Ionic content n_+	Ionic content n_-	Conductivity λ_+	Conductivity λ_-	Ionic mobility k_+	Ionic mobility k_-	Current-density, i	Radioactive content	Penetrating radiation L.M.T.	Penetrating radiation R	Ionization L.M.T.	Ionization η_0	ΔT	Q	Meteorological data L.M.T.	Pressure	Temp. Cent.	Rel. hm.	Wind True dir.	Wind Force	Clouds Kind	Clouds Am't	Weather
°	°	*1915*		h	$\left(\frac{v}{m}\right)$	h	$\left(\frac{ions}{cc}\right)$		(ESU×10⁻⁴)		$\left(\frac{cm/s}{v/cm}\right)$		(ESU× 10⁻⁷)	$\left(\frac{a\times 10^{-16}}{cm^3}\right)$	h	$\left(\frac{ions/cc}{s}\right)$	h	$\left(\frac{ions/cc}{s}\right)$	m	*	h	mm	°	p.ct.	°				
59.2 S	256.5	Dec	27	11.7	184	11.4	561	483	1.11	1.00	1.38	1.44	12.9	4.3	13.6	3.53	12.3	†0.43	5.0		12.2	725	6.5	77	346	6	Cu-Nb	6	bc
58.8 S	262.4		28	9.2	136	8.7	719														9.0	729	6.1	78	278	5	Ci-Cu	9	bcqr
			28	10.2	179	9.8	759	648	1.71	1.33	1.57	1.43	16.0	5.3						0.0	10.0	729	6.6	75	278	5	Ci-Cu	9	c
			28	11.2	153	10.8	759										10.9	†0.55	4.0		11.0	730	6.4	81	278	5	Ci-Cu	10	oq
			28			11.7	916														12.0	731	6.2	96	278	5	Ci		bcr
58.8 S	263.9		28	15.8	187	16.4	486														16.0	733	6.3	78	267	5	Cu-Nb	8	or
			28			17.4	497														17.0	733	6.3	75	267	5	Cu-Nb	8	oqr
58.8 S	268.2		29	10.5	177	11.6	655	491	1.37	1.10	1.45	1.56			12.0	3.70	11.0	0.36	9.6		10.9	739	5.4	85	232	4	Cu-Nb	10	or
58.8 S	271.2		30	9.6	174	9.5	676	495	1.39	1.05	1.43	1.48	14.2	4.7	11.1	3.38	10.1	0.23	8.2		10.0	742	5.1	80	175	3	Cu-Nb	10	o
58.8 S	272.8		30	13.9	177	13.4	673								13.4	3.47					13.7	743	6.5	60	163	2	Ci-Cu	3	bc
			30	14.9	124	14.3	726								14.3	3.43					14.7	742	6.4	58	186	2	Ci	2	bc
			30	15.9	120	15.2	676								15.3	3.48					15.7	743	6.5	58	208	2	Ci-Cu	2	bc
			30	16.9	102	16.3	676								16.4	3.38					16.7	743	7.3	59	208	1	Ci-Cu	3	bc
			30	17.9	104	17.3	628								17.3	3.29					17.7	743	7.5	60	208	1	Ci-Cu	1	bc
			30	18.9	87	18.2	593								18.3	3.40					18.7	743	5.8	63	208	1	Ci-Cu	1	bc
			30	19.9	104	19.4	641								19.3	3.85					19.7	744	5.3	61	253	1	Ci-Cu	3	bc
			30	20.9	108	20.3	651								20.4	3.33					20.7	742	4.3	65	231	1	Cu-Nb	9	o
			30	21.9	95	21.3	648								21.3	3.53					21.7	743	4.0	63	231	1	Cu-Nb	9	o
			30	22.9	100	22.3	655								22.3	3.21					22.7	743	4.0	62	253	2	Nb	10	o
			30	23.9	138	23.3	582								23.4	3.25					23.7	743	4.0	63	253	2	Nb	4	bc
			31	0.9	115	0.3	609								0.3	3.33					0.7	743	4.0	69	342	1	Nb	2	bc
			31	1.9	124	1.4	627								1.5	3.07					1.7	744	4.2	67	342	1	Cu	4	bc
			31	2.9	124	2.3	595								2.4	3.06					2.7	743	4.0	70	342	1	Cu	3	bc
			31	3.9	138	3.3	593								3.3	3.50					3.7	743	4.1	69	342	2	Cu	2	bc
			31	4.9	108	4.3	589								4.3	3.20					4.7	744	4.9	68	342	2	Cu-Nb	6	c
			31	5.9	140	5.3	599								5.3	3.60					5.7	743	5.0	72	342	2	Cu-Nb	9	c
			31	6.9	153	6.3	676								6.3	3.01					6.7	743	4.8	64	5	2	Cu-Nb	10	o
			31	7.9	133	7.3	765								7.3	3.26					7.7	742	5.0	64	5	3	Cu-Nb	10	o
			31	8.9	161	8.3	746								8.3	3.27					8.7	743	5.7	70	5	3	Cu-Nb	10	o
			31	9.9	167	9.3	719								9.4	3.15					9.7	743	6.3	74	5	4	Ci-Cu, Nb	10	o
			31	10.9	136	10.3	667								10.3	3.25					10.7	743	6.6	73	16	5	Ci-Cu	10	o
			31	11.8	155	11.3	753								11.4	3.18					11.7	743	6.5	74	16	5	Ci-Cu	10	o
			31	12.8	134	12.2	621								12.2	3.22					12.8	743	6.3	76	5	4			
		1916																											
59.2 S	279.5	Jan	1	10.0	201	9.9	412	288	1.19	0.90	2.01	2.17	14.0	4.7	11.6	3.53	10.8	†0.02	26.5		10.6	742	7.5	87	3	5	Cu-Nb	7	bc
59.8 S	290.6		3	10.0	193	10.2	451	360	0.76	0.55	1.17	1.06	8.4	2.8	11.3	3.55	10.7	0.26	9.2		10.5	742	8.2	73	335	4			bc
60.2 S	294.7		4	9.6	475	9.6	327		0.64		1.36				11.5	3.29	10.2	0.26	8.4		10.1	737	3.2	93	74	3			cfm
			4			[1]9.8		203		0.44		1.51	17.1	5.7															
			4			10.1		88		0.22		1.75																	
			4			10.3	186		0.27		1.01																		
59.4 S	296.9		5	10.0	203	10.1			0.76	0.60			9.2	3.1	11.6	3.53	10.6	0.24	8.0		10.4	741	6.6	87	308	4			bc
58.7 S	302.0		6	7.1	179																7.9	751	4.5	93	2	3	Ci	1	bc

*Curie×10⁻¹⁶ per cubic centimeter. †Not used in the computation of Q, irregular. [1] Fog came in thick after these observations.

58.7 S	302.0	Jan	6	8.1	200	...	...	...	...	...	...	...	...	...	...	...	...	...	...		8.9	751	5.3	89	13	3	Ci-Cu	8	bc
			6	9.1	205	...	...	...	...	...	...	...	...	...	...	...	...	...	...		9.9	751	5.0	87	13	5	Ci, Cu-Nb	8	bc
			6	10.1	228	9.8	484	344	1.07	0.80	1.54	1.62	14.2	4.7	...	...	...	...	...		10.9	751	5.0	89	13	6	Cu-Nb	10	os
			6	11.1	227	10.6	379	...	...	...	...	...	...	...	10.6	3.24	10.6	1.37	5.5		11.9	750	4.5	88	2	7	Cu-Nb	10	os
			6	12.1	162	11.6	243	...	...	...	...	...	...	...	11.6	3.29	...	...	...		12.9	749	4.6	88	350	7	Cu-Nb	10	os
57.9 S	307.2		7	10.1	221	10.1	...	...	1.29	0.88	...	...	16.0	5.3	11.9	3.47	10.8	†0.08	22.8		10.6	750	5.0	86	289	9	...	...	bo
55.6 S	315.4		9	10.3	112	10.2	733	517	1.61	1.39	1.53	1.87	11.2	3.7	12.0	3.65	11.0	0.47	7.7		10.7	750	5.7	86	138	1	Cu-Nb	10	o
54.5 S	318.5		10	9.6	68	9.7	792	765	1.48	1.41	1.30	1.28	6.6	2.2	11.0	3.56	10.1	0.58	9.0		9.8	754	4.7	93	268	3	Cu-Nb	10	om
South Georgia																													
54.3 S	326.8		15	10.6	166	10.7	664	602	1.38	1.18	1.44	1.36	14.2	4.7	12.2	3.75	11.3	0.51	5.3	0.3	11.2	740	4.0	85	253	6	Cu-Nb	10	o
54.5 S	344.3		19[1]	8.9	155	9.0	438	290	0.78	0.53	1.24	1.27	6.8	2.3	11.8	3.50	9.6	1.28	4.3		9.0	738	4.0	92	264	3	Cu-Nb	10	fmw
54.4 S	349.3		20	9.6	112	9.7	235	203	0.50	0.38	1.48	1.30	3.3	1.1	12.1	3.42	10.5	0.38	6.6		10.2	750	3.0	98	340	5	Cu-Nb	10	ofm
54.1 S	2.2		22	9.1	178	8.6	537	...	...	...	...	...	...	...	8.6	3.38	...	...	...		8.9	757	2.3	87	267	6	Ci	1	bo
			22	10.1	212	9.8	516	465	1.11	0.85	1.49	1.27	13.9	4.6	9.6	3.33	...	...	...		9.9	758	2.6	79	267	6	Ci	3	bo
			22	11.1	216	10.6	491	...	...	...	...	...	...	...	10.6	3.02	10.5	†0.51	5.4		10.9	757	2.6	77	267	6	Ci	2	bc
			22	12.1	247	11.5	484	...	...	...	...	...	...	...	11.5	3.33	...	...	...		11.9	757	2.6	79	267	6	Cu	2	bo
			22	13.1	208	12.5	465	...	...	...	...	...	...	...	12.5	2.99	...	...	...		12.9	757	2.7	77	267	6	Cu	2	bo
			22	15.1	224	14.5	425	...	...	...	...	...	...	...	14.5	3.37	...	...	...		14.9	755	3.0	78	267	6	Ci-Cu	3	bc
			22	16.1	188	15.6	445	...	...	...	...	...	...	...	15.6	3.43	...	...	...		15.9	756	2.4	84	267	6	Ci, Cu-Nb	7	bco
			22	17.1	240	16.6	478	...	...	...	...	...	...	...	16.6	3.47	...	...	...		16.9	755	1.7	90	279	6	Ci, Cu-Nb	7	bcs
			22	18.1	263	17.8	451	...	...	...	...	...	...	...	17.8	3.45	...	...	...		17.9	755	2.2	86	279	5	Cu-Nb	3	bcs
			22	[2]19.1	247	18.5	491	...	...	...	...	...	...	...	18.5	3.48	...	...	...		18.9	755	1.9	86	312	6	Cu-Nb	8	bo
			22	[3]20.1	209	19.6	432	...	...	...	...	...	...	...	19.5	3.41	...	...	...		19.9	754	1.4	90	312	6	Ci-Cu, Nb	8	ouf
			22	...	...	20.6	392	...	...	...	...	...	...	...	20.5	3.40	...	...	...		20.6	754	1.5	92	301	9	Cu	10	ouf
53.6 S	5.1		23	9.2	159	9.4	598	530	1.13	0.83	1.31	1.09	10.4	3.5	11.8	3.36	9.7	0.36	6.4		9.5	756	3.0	76	289	4	Nb, Cu	10	o
53.7 S	9.6		24	10.8	148	11.0	510	501	0.89	0.85	1.21	1.18	8.6	2.9	12.4	3.49	11.3	0.66	4.8		10.1	742	2.0	87	177	5	Cu-Nb	10	os
54.1 S	15.1		25	10.0	119	9.7	618	537	1.13	1.03	1.27	1.33	8.6	2.9	11.8	3.50	10.6	0.26	7.9		10.2	741	2.5	79	320	5	Nb	4	bo
54.5 S	20.8		26	10.3	97	10.1	471	442	1.08	0.92	1.59	1.45	6.5	2.2	11.9	3.53	10.9	0.23	8.0		10.6	742	2.0	84	354	5	Cu-Nb	10	o
54.2 S	26.4		27	10.4	93	10.3	537	451	1.23	1.05	1.59	1.62	7.1	2.4	12.2	3.46	10.9	0.30	6.0		10.3	736	2.0	90	353	2	Cu-Nb	10	ofwm
53.8 S	30.5		28	9.8	[4]193	9.5	471	413	0.56	0.49	0.83	0.82	6.7	2.2	12.0	3.67	10.3	0.30	6.6		10.0	737	1.4	85	252	5	Cu-Nb	10	osq
53.1 S	33.8		28	14.2	223	13.6	504	...	...	...	...	...	...	...	13.7	3.24	...	...	...		14.0	739	2.0	79	252	6	Ci, Cu-Nb	8	boq
			28	15.2	209	14.6	478	...	...	...	...	...	...	...	14.5	3.24	...	...	...		15.0	739	2.8	80	240	6	Cu	6	boq
			28	16.2	201	15.7	438	...	...	...	...	...	...	...	...	...	...	...	...		16.0	739	2.7	78	240	6	Cu-Nb	8	cs
			28	17.2	208	16.6	497	...	...	...	...	...	...	...	...	...	...	...	...		17.0	741	2.7	78	240	6	Cu-Nb	7	boq
			28	18.2	227	17.7	432	...	...	...	...	...	...	...	...	...	...	...	...		18.0	741	2.0	79	240	6	Cu-Nb	8	boq
			28	19.2	227	18.6	425	...	...	...	...	...	...	...	...	...	...	...	...		19.0	741	1.8	81	240	6	Cu-Nb	7	bo
			28	20.2	227	19.6	471	...	...	...	...	...	...	...	...	...	...	...	...		20.0	742	1.7	80	240	6	Nb	8	cq
			28	21.2	188	20.6	445	...	...	...	...	...	...	...	...	...	...	...	...		21.0	743	1.5	75	240	6	Nb	5	ooq
			28	22.2	239	21.7	451	...	...	...	...	...	...	...	...	...	...	...	...		22.0	743	1.6	75	240	6	Nb	7	bcq
			28	23.2	230	22.6	491	...	...	...	...	...	...	...	...	...	...	...	...		23.0	744	1.6	78	240	6	Nb	8	oq
			28	24.2	215	23.6	478	...	...	...	...	...	...	...	...	...	...	...	...		24.0	745	1.4	80	240	6	Nb	8	oq
			29	1.2	193	0.6	484	...	...	...	...	...	...	...	...	...	...	...	...		1.0	745	1.5	75	262	5	Cu-Nb	4	boq
			29	2.2	154	1.6	471	...	...	...	...	...	...	...	...	...	...	...	...		2.0	746	1.5	77	262	5	Cu-Nb	4	bc
			29	3.2	167	2.7	425	...	...	...	...	...	...	...	...	...	...	...	...		3.0	747	1.6	79	262	5	Cu-Nb	5	bo
			29	4.2	166	3.6	445	...	...	...	...	...	...	...	...	...	...	...	...		4.0	747	1.6	80	285	6	Cu-Nb	9	c
			29	5.2	162	4.7	399	...	...	...	...	...	...	...	...	...	...	...	...		5.0	746	1.6	80	285	6	Cu-Nb	8	c
			29	6.2	139	5.6	399	...	...	...	...	...	...	...	...	...	...	...	...		6.0	746	1.6	82	285	6	Cu-Nb	10	o
			29	7.2	154	6.6	487	...	...	...	...	...	...	...	...	...	...	...	...		7.0	745	2.1	82	285	6	Ci, Cu	8	c
			29	8.2	149	7.6	484	...	...	...	...	...	...	...	...	...	...	...	...		8.0	745	2.2	81	285	6	Ci, Cu	9	cs
			29	9.2	151	8.6	425	...	...	...	...	...	...	...	...	...	...	...	...		9.0	744	2.6	82	285	6	Cu	10	o
			29	10.2	156	...	...	...	...	...	...	...	...	...	...	...	...	...	...		10.0	744	3.0	80	285	6	Cu	10	o
			29	11.3	[5]213	...	...	...	...	...	...	...	...	...	...	...	...	...	...	0.0	11.0	744	3.0	78	285	6	Cu, Nb	10	o
			29	12.2	182	...	...	...	...	...	...	...	...	...	...	...	...	...	...		12.0	744	3.0	84	285	6	Cu, Nb	10	o
51.9 S	42.6		31	9.3	190	9.3	418	367	0.89	0.66	1.48	1.25	9.8	3.3	12.2	3.41	9.8	†5.62	4.0		9.6	741	3.5	84	250	7	Cu, Nb	10	om
49.8 S	47.0	Feb	1[6]	10.2	146	10.2	523	478	1.05	0.87	1.39	1.26	9.3	3.1	12.1	3.43	10.7	0.47	7.5		10.5	747	5.2	92	319	8	...	...	oc
48.6 S	50.6		4	10.0	134	9.6	...	...	1.18	1.00	...	...	9.7	3.2	12.0	3.39	10.6	0.55	7.1		10.3	760	7.2	84	336	4	Cu-Nb	10	o

†Not used in the computation of Q, in... [1] Heavy wet fog came in thick during latter half of these observations. [2] Lindsay Island 1 mile to southwest. [3] Heavy gale interrupted the series after this set. [4] Very sudden rise in P just as the snow squall struck the vessel. [5] Rain just left this set. [6] Observations interrupted by two heavy seas which drenched atmospheric-electric observatory and instruments.

FINAL RESULTS OF OCEAN ATMOSPHERIC-ELECTRIC OBSERVATIONS ON THE CARNEGIE, 1915–1921—*Continued.*

CRUISE IV, SOUTHERN OCEAN, 1915–1916—*Continued.*

Lat.	Long. E. of Gr.	Date	Potential gradient L. M. T.	Potential gradient P	Ionic cont-nt L. M. T.	Ionic cont-nt n_+	Ionic cont-nt n_-	Conductivity λ_+	Conductivity λ_-	Ionic mobility k_+	Ionic mobility k_-	Current-density, i	Current-density, i	Penetrating radiation L. M. T.	Penetrating radiation R	Radioactive cont-nt L. M. T.	Radioactive cont-nt Ionization η_0	Radioactive cont-nt ΔT	Q	Meteorological data L. M. T.	Pressure	Temp. Cent.	Rel. hm.	Wind True dir.	Wind Force	Clouds Kind	Clouds Am't	Weather
°	°	*1916*	h	(v/m)	h	(ions/cc)		($ESU\times10^{-4}$)		(cm/s / v/cm)		($ESU\times10^{-7}$)	($a\times10^{-18}$/cm²)	h	(ions/cc / s)	h	(ions/cc / s)	m	*	h	mm	°	p. ct.	°				
49.0 S	63.5	Feb 5	9.9	93	9.8	491	...	1.24	1.07	1.76	...	7.2	2.4	12.1	3.55	10.3	0.19	11.9		10.0	759	6.3	82	235	4	Cu–Nb	10	ofmr
49.3 S	65.9	5	18.9	273	...	...	...	...	...	...	...	...	...	...	...	...	...	...		19.1	762	5.0	86	235	2	Ci	1	b
		5	19.9	275	...	...	...	...	...	...	...	...	...	...	...	...	...	...		20.1	762	5.0	86	235	2	Ci	2	b
		5	20.9	256	...	...	...	...	...	...	...	...	...	...	...	...	...	...		21.1	763	5.0	89	235	2	Ci	1	b
		5	21.9	292	...	...	...	...	...	...	...	...	...	...	...	...	...	...		22.1	763	5.0	91	235	2	Ci	1	b
		5	22.9	275	...	...	...	...	...	...	...	...	...	...	...	...	...	...		23.1	763	5.0	89	235	2	Nb	7	bc
		5	23.9	256	...	...	...	...	...	...	...	...	...	...	...	...	...	...		24.1	763	5.0	89	235	2	Nb	10	o
		6	0.9	242	...	...	...	...	...	...	...	...	...	...	...	...	...	...		1.1	763	5.0	86	254	3	Cu–Nb	10	o
		6	1.9	223	...	...	...	...	...	...	...	...	...	...	...	...	...	...		2.1	764	5.4	83	254	3	Cu–Nb	6	bc
		6	2.9	227	...	...	...	...	...	...	...	...	...	...	...	...	...	...		3.1	763	5.5	86	254	3	Cu–Nb	10	o
		6	3.9	201	...	...	...	...	...	...	...	...	...	...	...	...	...	...		4.1	762	5.0	86	254	2	Cu–Nb	10	o
		6	4.9	212	...	...	...	...	...	...	...	...	...	...	...	...	...	...		5.1	763	5.0	94	254	3	Cu–Nb	10	o
		6	5.9	[1]−80	...	...	...	...	...	...	...	...	...	...	...	...	...	...		6.1	762	5.1	92	254	2	Cu–Nb	10	or
		6	6.9	157	...	...	...	...	...	...	...	...	...	...	...	...	...	...		7.1	761	5.3	92	344	3	Cu–Nb	10	o
		6	7.9	187	...	...	...	...	...	...	...	...	...	...	...	...	...	...		8.1	760	5.0	89	29	4	Cu–Nb	10	o
		6	8.9	191	...	...	...	...	...	...	...	...	...	...	...	...	...	...		9.1	759	5.6	87	29	5	Cu–Nb	10	o
		6	9.9	186	...	...	...	...	...	...	...	...	...	...	...	...	...	...		10.1	758	5.7	86	29	5	Ci, Cu	10	o
		6	10.9	157	...	...	...	...	...	...	...	...	...	...	...	...	...	...		11.1	757	6.1	85	29	5	Ci, Cu, Nb	10	o
51.0 S	70.6	7[2]	11.4	221	11.1	413	315	0.93	0.80	1.57	1.77	12.7	4.2	14.1	3.98	12.0	0.56	5.7		11.8	741	4.5	86	297	9	Cu–Nb	8	oc
52.0 S	74.5	8	9.8	154	9.7	609	491	1.10	0.85	1.26	1.20	10.0	3.3	12.2	3.69	10.2	0.30	7.0		10.0	749	3.0	92	217	8	Cu–Nb	7	bcqr
51.3 S	77.6	9	10.3	144	10.2	510	438	1.08	0.84	1.47	1.33	9.2	3.1	11.9	3.52	10.8	0.34	6.0		10.6	754	3.6	85	250	5	Cu–Nb	8	bc
47.4 S	83.4	11	9.8	[3]130	9.6	759	635	1.06	0.85	0.97	0.93	8.3	2.8	11.6	3.23	10.8	†0.08	17.5	......	9.9	750	4.6	86	239	8	Cu–Nb	10	orm
44.4 S	86.3	12	9.8	138	9.9	733	641	1.33	1.08	1.27	1.17	11.1	3.7	11.9	3.36	10.5	0.90	5.3		10.2	754	8.2	85	224	7	Cu–Nb	......	bcq
41.4 S	88.4	13	9.2	131	9.3	811	726	1.42	1.06	1.21	1.02	10.8	3.6	11.8	3.26	9.9	0.41	7.2		9.6	761	9.8	75	195.	6	Cu–Nb	8	cqr
38.6 S	90.2	14	10.2	133	...	...	...	...	...	...	...	...	...	11.8	3.31	10.2	0.49	4.5		10.5	764	15.0	75	299	6	Ci, Cu, Nb	10	oc
35.7 S	93.5	15	9.7	131	9.5	759	621	1.57	1.40	1.44	1.57	13.0	4.3	...	...	...	...	...		9.8	766	19.5	62	293	3	Cu–Nb	7	bc
		15	11.0	134	10.3	759	...	...	...	...	...	...	...	10.2	3.29	10.2	†0.23	6.2		10.8	766	18.5	56	293	3	Cu–Nb	7	bc
		15	12.0	135	11.4	680	...	...	...	...	...	...	...	11.5	3.38	...	...	...		11.8	766	19.0	65	293	3	Ci–Cu	8	bco
		15	13.0	[4]92	12.4	707	...	...	...	...	...	...	...	12.5	3.26	...	...	...		12.8	766	18.2	67	293	3	Cu, Nb	10	o
		15	14.0	148	13.4	707	...	...	...	...	...	...	...	13.4	3.24	...	...	...		13.8	765	18.0	73	270	3	Ci–Cu, Nb	8	co
		15	15.0	136	14.4	707	...	...	...	...	...	...	...	14.4	3.21	...	...	...		14.8	765	20.0	66	293	3	Ci–Cu	3	b
		15	16.0	144	15.4	694	...	...	...	...	...	...	...	15.5	3.31	...	...	...		15.8	765	20.5	65	293	3	Ci–Cu	3	b
		15	17.0	170	16.4	667	...	...	...	...	...	...	...	16.4	3.40	...	...	...		16.8	765	20.3	62	270	3	Ci–Cu	6	bc
		15	18.0	166	17.4	655	...	...	...	...	...	...	...	17.5	3.19	...	...	...		17.8	765	18.5	74	270	3	Ci–Cu, Nb	7	c
		15	19.0	177	18.4	582	...	...	...	...	...	...	...	18.4	3.38	...	...	...		18.8	765	17.8	78	270	3	Nb	3	bc
		15	20.0	159	19.4	516	...	...	...	...	...	...	...	19.4	3.41	...	...	...		19.8	766	17.5	78	248	3	Cu–Nb	6	bcq
		15	21.1	122	20.5	557	...	...	...	...	...	...	...	20.4	3.04	...	...	...		20.8	767	17.0	90	203	3	Cu–Nb	10	oqr
34.5 S	96.0	16	9.0	157	8.4	563	...	...	...	...	...	...	...	8.3	3.18	...	...	...		8.7	769	16.0	67	149	2	Ci	1	b
		16	10.0	156	9.6	563	445	1.26	1.00	1.56	1.56	11.8	3.9	9.3	3.29	...	...	...		9.7	769	16.3	66	149	3	Ci	0-1	b
		16	11.0	156	10.4	537	...	...	...	...	...	...	...	10.4	3.10	10.4	†0.30	5.2		10.7	769	16.5	66	149	3	Ci	1	b
		16	12.0	144	11.4	537	...	...	...	...	...	...	...	11.4	3.18	...	...	...		11.7	769	16.5	66	149	3	Ci	1	b
		16	13.0	172	12.3	530	...	...	...	...	...	...	...	12.3	3.21	...	...	...		12.7	769	17.0	63	138	3	Cu	1	b

* Curie $\times10^{-18}$ per cubic centimeter. † Not used in the computation of Q, irregular. [1] Negative potential; misting, lowering clouds all around. [2] Gigantic seas. [3] Low-hanging clouds approaching; set interrupted by rain. [4] Heavy low-hanging cumulus clouds; potential gradient rose suddenly during latter half, with change in cloud position.

34.5 S	96.0	Feb	16	14.0	172	13.4	530								13.4	3.07					13.7	769	16.7	63	138	3	Cu	2	bc
			16	15.0	144	14.4	530								14.4	3.10					14.7	769	16.8	67	138	4	Cu	6	bc
			16	16.0	164	15.4	510								15.4	3.14					15.7	769	16.8	67	138	4	Cu	8	o
			16	17.0	151	16.4	510								16.4	3.26					16.7	769	16.5	65	138	4	Cu	8	o
			16	18.0	171	17.4	497								17.4	3.31					17.7	769	16.4	71	138	4	Cu–Nb	8	ou
			16	19.0	175	18.4	543								18.3	3.54					18.7	769	16.2	67	138	4	Cu–Nb	7	o
			16	20.0	172	19.4	556														19.7	770	16.3	66	138	4	Cu–Nb	8	oq
			16	21.0	176	20.4	515														20.7	770	15.8	66	138	4	Cu–Nb	10	o
			16	22.0	201	21.4	564														21.7	771	15.7	67	138	4	Ci, Nb	9	bc
			16	23.0	171	22.4	572														22.7	771	15.6	71	138	4	Cu–Nb	10	o
			16	24.0	184	23.4	606														23.7	772	16.0	66	138	4	Cu–Nb	10	o
			17	1.0	179	0.4	564														0.7	771	15.7	68	138	4	Nb	10	o
			17	2.0	216	1.4	589													0.6	1.7	773	15.5	71	138	4	Cu–Nb	10	o
			17	3.0	161	2.3	597														2.7	772	15.6	73	138	4	Cu–Nb	10	o
			17	4.0	164	3.3	597														3.7	772	16.0	71	138	4	Cu–Nb	8	o
			17	5.0	149	4.3	589														4.7	771	15.5	70	127	5	Cu–Nb	9	o
			17	6.0	157	5.3	630														5.7	772	15.5	70	127	5	Cu–Nb	10	o
			17	7.0	134	6.4	630														6.7	772	15.5	70	127	5	Cu–Nb	10	o
			17	8.0	103	7.3	670														7.7	772	15.5	73	127	4	Cu–Nb	10	o
36.2 S	95.4		18	9.8	77	9.7	600	530	1.35	1.22	1.54	1.60	6.6	2.2	12.3	3.41	10.5	0.34	4.6		10.2	770	16.0	86		0	Cu–Nb	10	o
37.2 S	97.5		20	9.8	155	9.7	516	425	1.03	0.85	1.39	1.39	9.7	3.2	12.0	3.10	10.4	0.11	10.2		10.2	764	17.6	82	316	3	Cu–Nb	9	o
39.7 S	99.0		21	9.8	141	9.8	606	572	1.56	1.37	1.79	1.66	13.8	4.6	12.2	3.41	10.3	0.60	4.6		10.1	764	13.0	86	213	7	A–Cu, Nb	6	bc
42.0 S	100.4		22	9.8	145	9.8	673	609	1.31	1.03	1.35	1.18	11.3	3.8	12.5	3.35	10.6	2.12	3.5		10.2	763	13.5	86	266	6	Cu–Nb	8	o
47.8 S	102.0		24	8.9	232	8.8	478	413	0.79	0.70	1.15	1.18	11.5	3.8	10.2	3.36	9.4	0.47	4.6		9.2	754	7.0	94	271	3	Cu–Nb	10	o
48.2 S	104.1		25	10.1	151	10.0	609	471	1.46	1.19	1.67	1.76	13.8	4.4							10.4	754	6.2	87	148	2	Cu–Nb	6	bc
			25	11.1	166	10.7	596								10.7	3.41	10.6	†0.71	4.1		10.9	754	6.2	86	148	2	Cu–Nb	8	cs
			25	12.1	174	11.5	648								11.6	3.40					11.9	753	6.5	74	148	2	Cu–Nb	8	bc
			25	13.1	169	12.5	694								12.6	3.41					12.9	752	7.0	70	148	2	Cu–Nb	2	bc
			25	14.2	208	13.5	713								13.5	3.13					13.9	752	7.0	68	148	1	Cu	6–8	bc
			25	15.1	182	14.5	732								14.5	3.29					14.9	751	7.3	68	180	2	Cu	6	bc
			25	16.1	202	15.5	641								15.5	3.29					15.9	751	7.3	68	180	2	Ci–Cu	6	bc
			25	17.1	187	16.5	667								16.5	3.45					16.9	750	7.1	68	180	3	Nb, Ci–Cu	8	bc
			25	18.1	190	17.6	667								17.6	3.47					17.9	750	6.5	74	180	3	Nb, Ci–Cu	7	bc
			25	19.1	164	18.5	628								18.5	3.47					18.9	750	5.7	73	180	3	Nb, Ci–Cu	4	bc
			25	20.1	217	19.5	635								19.5	3.50					19.9	749	5.0	78	236	2	Nb	1	b
			25	21.1	219	20.6	648								20.5	3.50					20.9	749	5.2	73	236	3	Nb	9	o
			25	22.1	243	21.5	628								21.5	3.63					21.9	747	5.5	73	281	3	Cu–Nb	6	bc
			25	23.1	216	22.5	589								22.5	3.60					22.9	746	5.5	79	281	3	Cu, Cu–St	10	o
			25	24.1	186	23.5	614								23.5	4.09					23.9	745	5.5	79	270	4	Cu–Nb	10	ou
			26	1.1	247	0.6	589								0.6	3.43					0.9	743	5.3	82	270	5	Cu, Nb	9	o
			26	2.1	171	1.6	523														1.9	743	6.0	83	270	6	Cu, Nb	10	o
			26	3.2	128	2.5	508														2.9	742	5.8	90	270	6	Cu, Nb	10	or
			26	8.5	175																6.9	736	6.2	83	214	6	Nb, Cu	6–9	bc
54.3 S	107.6		28	10.6	120	10.4	638	499	1.34	1.13	1.46	1.57	9.9	3.3	11.5	3.54					10.8	739	5.1	92	286	4		10	omsr
59.1 S	109.9	Mar	1	10.6	170	10.6	824	700	1.76	1.33	1.48	1.32	17.5	5.8	13.7	3.51	11.2	0.58	4.8		11.0	718	3.0	84	272	6			bcs
57.2 S	112.4		2	9.7	239	9.5	615	510	1.22	1.00	1.38	1.36	17.4	5.8	12.1	3.43	10.4	0.55	4.0		9.8	742	3.4	86	204	7		10	orqs
54.0 S	113.7		3	10.0	181	9.8	510	413	1.06	0.88	1.45	1.48	11.6	3.9	12.3	3.41	10.7	†0.96	4.4		10.2	757	3.5	81	237	6		10	os
51.6 S	115.8		4	8.8	180	8.8	484	399	1.17	0.92	1.68	1.00	12.5	4.2	11.6	3.43	9.5	†0.15	15.2		9.3	752	4.7	90	335	4	Cu–Nb	10	od
44.4 S	126.6		9	9.6	269	9.5	772	568	1.78	1.42	1.60	1.74	27.6	9.2							9.6	755	8.5	88	266	7	Ci–Cu	7	bcq
40.7 S	130.1		12	8.0	99																8.2	755	15.2	85	248	2	Ci–Cu	7	bc
			12	9.0	115																9.2	755	15.1	85	248	2	Ci–Cu	4	bc
			12	10.0	119	9.7			1.22	1.08			9.1	8.0							10.2	756	16.5	81	270	2	Ci–Cu	6	bc
			12	11.0	99												10.7	†0.02	35.3		11.2	756	16.5	77	270	2	Ci–Cu	6	bc
			12	12.0	97																12.2	756	16.0	81	270	2	Ci–Cu	7	bc
			12	13.0	113										13.5	3.29					13.2	755	15.8	83	270	2	Ci–Cu	8	q
			12	14.0	124																14.2	755	15.7	84	270	2	Ci–Cu	8	bcqr

†Not used in the computation of Q, irregular. [1] Rain interrupted.

FINAL RESULTS OF OCEAN ATMOSPHERIC-ELECTRIC OBSERVATIONS ON THE CARNEGIE, 1915–1921—*Continued.*

CRUISE IV, SOUTHERN OCEAN, 1915–1916—*Continued.*

Lat.	Long. E. of Gr.	Date	Potential gradient L. M. T.	Potential gradient P	Ionic content L. M. T.	Ionic content n_+	Ionic content n_-	Conductivity λ_+	Conductivity λ_-	Ionic mobility k_+	Ionic mobility k_-	Current-density, i	Current-density, i	Penetrating radiation L. M. T.	Penetrating radiation R	Radioactive content, Ionization L. M. T.	Radioactive content, Ionization q_e	Radioactive content ΔT	Q	Meteorological data L. M. T.	Pressure	Temp. Cent.	Rel. hm.	Wind True dir.	Wind Force	Clouds Kind	Clouds Am't	Weather
°	°	*1916*	h	$\left(\frac{v}{m}\right)$	h	$\left(\frac{ions}{cc}\right)$		(ESU×10⁻⁴)		$\left(\frac{cm/s}{v/cm}\right)$		(ESU× 10⁻⁷)	$\left(\frac{a\times10^{-18}}{cm^2}\right)$	h	$\left(\frac{ions/cc}{s}\right)$	h	$\left(\frac{ions/cc}{s}\right)$	m	*	h	mm	°	p. ct.	°				
40.7 S	130.1	Mar 12	15.0	124	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	15.2	754	15.6	85	270	2	Ci-Cu	5	bc
		12	16.0	128	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	16.2	754	15.5	85	270	2	Ci, Cu	10	o
		12	17.0	131	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	17.2	754	15.6	84	270	2	Cu	9	c
		12	18.0	119	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	18.2	755	14.7	88	281	3	Cu-Nb	10	o
		12	19.0	129	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	19.2	754	14.6	90	281	4	Cu-Nb	10	o
		12	20.0	131	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	20.0	755	14.6	90	281	4	...	...	oq
43.7 S	131.0	13	10.8	122	11.0	539	419	1.11	0.88	1.43	1.46	8.1	2.7	...	...	11.3	0.47	4.7		11.1	753	13.5	90	270	4	Cu-Nb	2	bc
		13	12.1	143	...	...	...	...	...	...	...	...	...	...	...	...	...	...		12.3	753	13.4	82	270	4	Ci-Cu	2	bc
		13	13.1	133	...	...	...	...	...	...	...	...	...	...	...	...	...	...		13.3	753	13.5	78	270	4	Ci-Cu	2	bc
		13	14.1	136	...	...	...	...	...	...	...	...	...	...	...	...	...	...		14.3	752	13.3	81	281	5	Ci-Cu	9	c
		13	15.1	156	...	...	...	...	...	...	...	...	...	14.6	3.62	...	...	...		15.3	751	13.1	82	281	5	Ci-Cu, Nb	8	cq
		13	16.1	138	...	...	...	...	...	...	...	...	...	...	...	...	...	...		16.3	751	12.8	85	281	5	Ci-Cu	9	c
		13	17.6	157	...	...	...	...	...	...	...	...	...	...	...	...	...	...		17.3	751	12.0	89	281	5	Ci-St, Nb	9	cqr
		13	19.1	170	...	...	...	...	...	...	...	...	...	...	...	...	...	...		19.3	751	12.0	88	281	5	Ci-Cu, Nb	6	bc
		13	20.1	176	...	...	...	...	...	...	...	...	...	...	...	...	...	...		20.3	750	12.3	84	281	5	Ci-Cu	2	bcw
		13	21.1	148	...	...	...	...	...	...	...	...	...	...	...	...	...	...		21.3	751	12.0	84	281	5	Cu-Nb	3	bcw
		13	22.1	164	...	...	...	...	...	...	...	...	...	...	...	...	...	...		22.3	750	12.3	80	281	5	Cu-Nb	7	bc
		13	23.3	192	...	...	...	...	...	...	...	...	...	...	...	...	...	...		23.3	750	12.0	80	281	6	Cu-Nb	9	cqr
		13	24.0	139	...	...	...	...	...	...	...	...	...	...	...	...	...	...		24.0	750	12.5	89	281	5	...	...	oqr
46.5 S	130.9	14[1]	11.7	156	11.6	785	664	1.30	1.08	1.15	1.13	12.4	4.1	13.7	3.80	12.2	0.38	5.4		12.1	742	11.6	82	303	6	...	...	bc
48.6 S	132.7	15	9.9	154	9.8	749	504	1.50	1.08	1.39	1.49	13.2	4.4	13.5	3.81	10.6	0.45	4.3		10.4	752	9.5	88	224	5	Cu-Nb	9	o
56.8 S	135.4	19	10.5	201	10.4	621	526	1.21	1.06	1.35	1.40	15.2	5.1	13.5	3.43	11.4	1.39	4.0		11.0	757	5.5	86	287	7	...	...	bc
57.1 S	140.0	20	9.0	141	8.4	628	...	...	...	...	...	...	...	...	...	...	...	...		8.8	761	5.0	89	280	2	Ci	1	bc
		20	10.0	144	9.4	628	...	...	...	...	...	...	...	...	...	...	...	...		9.8	761	5.1	89	280	1	Ci	1	bc
		20	11.0	117	10.4	596	...	...	...	...	...	...	...	...	...	...	...	...		10.8	761	5.5	86	280	1	Ci	1	bc
		20	12.0	139	11.4	614	...	...	...	...	...	...	...	...	...	...	...	...		11.8	761	5.6	85	280	1	Ci	1	bc
		20	13.0	122	12.4	621	...	...	...	...	...	...	...	...	...	...	...	...		12.8	760	5.7	85	280	1	Ci	1	bc
		20	14.0	115	13.4	621	...	...	...	...	...	...	...	...	...	...	...	...		13.8	761	6.5	80	291	1	Ci-St	2	bc
		20	15.3	94	14.4	621	...	...	...	...	...	...	...	...	...	...	...	...	0.5	14.8	761	5.0	86	291	1	Ci, Nb	7	c
		20	16.0	100	16.7	614	...	...	...	...	...	...	...	...	...	...	...	...		15.8	761	5.0	89	291	2	Cu-Nb	10	oqr
		20	17.0	117	17.4	614	...	...	...	...	...	...	...	...	...	...	...	...		16.8	761	5.0	89	291	2	Cu-Nb	10	oqu
		20	18.0	94	18.4	628	...	...	...	...	...	...	...	...	...	...	...	...		17.8	761	4.2	91	314	2	Cu-Nb	10	oq
		20	19.0	124	19.4	694	...	...	...	...	...	...	...	...	...	...	...	...		18.8	762	4.0	91	314	2	Nb	10	o
		20	20.0	148	20.4	621	...	...	...	...	...	...	...	...	...	...	...	...		19.8	762	3.6	91	336	3	Cu, Nb	10	o
		20	21.0	126	21.4	602	...	...	...	...	...	...	...	...	...	...	...	...		20.8	762	3.5	92	336	3	Nb	10	o
		20	22.0	166	22.4	667	...	...	...	...	...	...	...	...	...	...	...	...		21.8	762	3.4	92	336	3	Cu	10	o
		20	23.0	167	23.4	635	...	...	...	...	...	...	...	...	...	...	...	...		22.8	761	3.4	88	336	3	Cu-Nb	10	o
		20	24.0	138	24.4	621	...	...	...	...	...	...	...	...	...	...	...	...		23.8	761	3.5	86	336	3	Cu-Nb	10	o
		21	1.0	247	1.4	563	...	...	...	...	...	...	...	...	...	...	...	...		0.8	761	3.4	90	352	4	Cu	9	c
		21	2.0	175	2.4	582	...	...	...	...	...	...	...	...	...	...	...	...		1.8	761	3.5	92	352	4	Cu	8	c
		21	3.0	185	3.4	537	...	...	...	...	...	...	...	...	...	...	...	...		2.8	761	3.5	92	352	4	Cu	6	bc
		21	4.0	228	4.4	458	...	...	...	...	...	...	...	...	...	...	...	...		3.8	760	3.6	91	352	4	Cu-Nb	7	bc

* Curie×10⁻¹⁸ per cubic centimeter. [1] Rain during earlier part of forenoon.

57.1 S	140.0	Mar	21	5.0	285	[1] 5.4	556														4.8	759	2.7	97	352	5	Cu-Nb	10	ow
			21	6.0	205																5.8	759	2.2	97	352	5	Cu-Nb	10	omf
			21	7.0	269																6.8	759	2.2	98	353	5	Cu-Nb	10	omf
			21	[1] 7.9	257																7.8	759	1.6	100	353	5	Cu-Nb	10	omf
52.9 S	154.4		25	11.8	163	11.8	743	635							13.9	3.19	12.5	0.38	5.9		12.2	750	7.7	78	241	4	Cu-Nb, St	4	bc
51.2 S	160.5		27	10.0	185	10.1	614	564							11.9	3.57	10.6	0.28	6.0		10.2	747	10.0	82	321	7	Ci-St, Cu	4	bc
48.6 S	164.0		28	10.6	151	11.7	678	606							14.5	[2] 3.57	11.1	0.32	5.4		10.9	765	9.4	76	197	5	Cu	9	c
48.0 S	167.5		29[3]	9.4	110	9.5	788	609							11.2	3.41	10.1	0.32	5.4		9.8	771	11.3	85	322	4	Cu-Nb	8	bc
46.3 S	171.0		30[4]	10.1	166	10.0	576	427							14.9	3.58	10.6	12.97	3.0	0.6	10.4	770	11.3	91	299	4	Cu, Ci-St	4	bc
44.8 S	172.9		31[4]	10.0	129	9.7	732	621							11.8	3.66	10.7	6.27	3.1		10.4	771	13.0	91	332	2	Cu-Nb	10	o
Lyttelton																													

CRUISE IV, PACIFIC OCEAN, 1916–1917.

°	°	1916		h	$\left(\frac{v}{m}\right)$	h	$\left(\frac{ions}{cc}\right)$		$(ESU\times10^{-4})$		$\left(\frac{cm/s}{v/cm}\right)$		$(ESU\times 10^{-7})$	$\left(\frac{a\times10^{-16}}{cm^2}\right)$	h	$\left(\frac{ions/cc}{s}\right)$	h	$\left(\frac{ions/cc}{s}\right)$	m	°	h	mm	°	p.ct.	°				
Lyttelton																													
43.8 S	174.4	May	18	9.4	231	10.0			1.70	1.20					11.2	3.06					10.0	772	12.5	82	40	2	Ci-St		bc
43.0 S	174.3		19	8.8	234										9.4	2.75					9.0	769	12.9	96	83	3			fm
43.6 S	175.9		20	9.6	195	10.0			0.48						10.9	2.52	10.3	0.00			10.2	762	14.6	97	17	3			bcm
44.0 S	176.6		21	11.1	262												11.5	0.00			11.4	759	13.8	88	344	4	Ci		bcf
44.0 S	178.1		22	9.7	215	10.0	477	282	0.33	0.74	4.81	1.83	7.7	2.6	11.4	4.06	10.3	5.21	6.0		10.1	761	13.0	95	18	4	Ci	1	b
43.8 S	181.6		22[5]	9.7	308	9.9	356	203							11.0	3.10					10.5	755	14.9	94	321	5			bcw
41.4 S	184.2		23	10.4	205										12.1	1.31	10.9	1.88	8.0		10.8	759	16.7	88	298	6			bcm
39.9 S	185.7		24	10.5	292	10.9	557	293	0.96	0.65	1.20	1.54	15.7	5.2	12.5	4.84	11.8	1.52	7.1		11.8	764	16.7	91	275	2			bc
37.1 S	186.5		25	9.4	134	9.8	718	460	1.76	1.44	1.71	2.13	14.3	4.8	10.7	3.41					9.9	770	16.5	87	128	5	Cu-Nb	9	c
32.6 S	187.0		26	8.8	141	8.1	941														8.5	769	18.3	84	82	4	Cu-Nb		bc
			26	9.8	138	9.2	853														9.5	769	18.7	83	82	4	Cu-Nb		bc
			26	10.8	130	10.2	919														10.5	769	18.7	86	82	4	Cu-Nb		bc
			26	11.8	134	11.2	848														11.5	769	18.4	86	82	4	Cu-Nb		bc
			26	12.8	107	12.2	818														12.5	768	18.6	84	82	4	Cu-Nb		bc
			26	13.8	123	13.2	789														13.5	767	18.3	85	82	4	Cu-Nb		bc
			26	14.8	120	14.2	937														14.5	768	18.3	81	82	4	Cu-Nb		bc
			26	15.8	117	15.2	900														15.5	767	19.0	80	82	4	Cu-Nb		bc
			26	16.8	88	16.2	708														16.5	767	18.3	83	70	4	Cu-Nb		bc
			26	17.8	133	17.2	700														17.5	767	18.2	86	70	4	Cu-Nb		bcw
			26	18.8	155	18.2	701														18.5	767	18.2	87	82	5	Cu-Nb		bc
			26	19.8	181	19.2	667													2.4	19.5	768	18.5	84	82	5	Cu-Nb		bcqr
			26	20.8	212	20.2	638														20.5	767	18.6	84	70	5			cr
			26	21.8	130	21.2	668														21.5	767	18.8	84	59	5			cr
			26	22.8	167	22.4	807														22.5	767	18.6	84	59	5			cr
			26	23.8	160	23.2	871														23.5	767	18.7	84	59	5			cqr
			27	0.8	141	0.2	767														0.5	767	18.8	84	59	5			cr
			27	1.8	149	1.2	722														1.5	766	18.3	92	59	5	Cu-Nb	4	bcw
			27	2.8	156	2.2	669														2.5	766	18.5	92	59	5	Cu-Nb	3	bcm
			27	3.8	171	3.2	673														3.5	766	18.9	85	59	5	Cu-Nb	4	bcm
			27	4.8	164	4.2	636														4.5	765	19.1	85	59	5	Cu-Nb	7	bcr
			27	5.8	174	5.1	631														5.5	765	19.0	89	59	5	Cu-Nb	7	bcr
			27	6.8	181																6.5	765	19.5	82	48	5			bcmr
			27	7.8	141																7.5	765	20.1	78	37	5			bcmr
31.0 S	186.1		28	10.1	166	10.3			1.18	1.00			12.1	4.0	11.5	3.76	10.7	0.00			10.5	763	21.5	92	351	5	Cu-Nb	10	o
30.6 S	187.7		29	10.0	110	10.0			1.26	1.04			8.3	2.8	11.7	3.72	10.7	0.00			9.6	764	21.0	94	339	4	Cu-Nb	10	o
28.9 S	189.1		31	9.6	104	10.1	591	391	1.61	1.57	1.89	2.79	11.0	3.7	11.5	2.39					9.8	762	21.7	83	351	3			bc
27.2 S	191.6	Jun	1	9.3	138	9.7			2.33	1.97			19.8	6.6	11.6	2.14	9.9	2.30	2.7		9.7	758	21.5	79	260	5	Cu	3	bc

*Curie $\times10^{-12}$ per cubic centimeter. [1] Observations interrupted by heavy, wet fog spoiling insulation. [2] The usual morning determination for penetrating radiation was left until the afternoon in order that experiments might be made to test for a leak which might account for the low value of *R* obtained with penetrating-radiation apparatus No. 1. [3] Off coast of New Zealand. [4] A few miles off the coast of New Zealand; leeway from land. [5] Crossed 180th meridian, hence date May 22 repeated.

FINAL RESULTS OF OCEAN ATMOSPHERIC-ELECTRIC OBSERVATIONS ON THE CARNEGIE, 1915–1921—*Continued.*

CRUISE IV, PACIFIC OCEAN, 1916–1917—*Continued.*

Lat.	Long. E. of Gr.	Date		Potential gradient L.M.T.	Potential gradient P	L.M.T.	Ionic content n_+	Ionic content n_-	Conductivity λ_+	Conductivity λ_-	Ionic mobility k_+	Ionic mobility k_-	Current-density, i	Current-density, i	Penetrating radiation L.M.T.	Penetrating radiation R	Radioactive content* Ionisation L.M.T.	Ionisation q_0	AT	Q	Meteorological data L.M.T.	Pressure	Temp. Cent.	Rel. hm.	Wind True dir.	Wind Force	Clouds Kind	Clouds Am't	Weather
°	°	*1916*		h	$\left(\frac{v}{m}\right)$	h	$\left(\frac{ions}{cc}\right)$		$(ESU\times10^{-4})$		$\left(\frac{cm/s}{v/cm}\right)$		$(ESU\times10^{-7})$	$\left(\frac{a\times10^{-16}}{cm^2}\right)$	h	$\left(\frac{ions/cc}{s}\right)$	h	$\left(\frac{ions/cc}{s}\right)$	m	*	h	mm	°	p.ct.	°				
24.7 S	191.6	Jun	2	10.5	148	10.5	630	510	2.28	1.53	2.51	2.09	18.8	6.3	12.1	1.87	11.1	1.41	3.0		10.9	760	22.4	70	.....	0	Cu, St-Cu	4	bcqr
23.0 S	191.2		3	9.6	95	9.8	713	495	1.99	1.84	1.93	2.58	13.1	4.0	11.5	2.32	10.3	6.26	5.3		10.1	762	23.5	76	79	4	Ci-Cu, Nb	9	co
18.6 S	189.1		5	10.4	114	10.7	429	267	2.07	1.84	3.35	4.79	14.9	5.0	11.9	3.01	10.9	0.00	......	......	10.6	760	26.4	86	89	2	......	......	bc
Pago Pago, Samoa																													
12.1 S	189.0		20	9.6	159	10.2	671	557	1.31	1.20	1.36	1.50	......	......	11.4	3.21	10.3	0.71	3.4		10.1	760	28.3	79	100	5	......	......	bc
9.4 S	189.5		21	10.2	138	[1]9.3	.....	358	......	1.04	......	2.02	......	......	11.3	2.66	......	......	......		10.5	758	27.3	83	54	4	Nb	......	bcrq
6.9 S	189.0		22	9.7	128	9.9	539	413	1.78	1.01	2.29	1.70	11.9	4.0	11.6	2.44	10.4	0.47	4.6		9.9	758	28.3	74	65	5	......	......	bc
2.9 S	187.6		23	8.9	140	8.3	361	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....		8.5	762	28.1	83	76	4	Cu	......	bc
			23	9.8	157	9.3	330	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....		9.5	760	28.2	80	76	4	Cu	......	bc
			23	10.8	131	10.3	341	.....	.....	.....	.....	.....	.....	.....	10.4	2.23	.....	.....	.....		10.5	759	28.2	80	76	4	Cu	......	bc
			23	11.8	139	11.3	282	.....	.....	.....	.....	.....	.....	.....	11.8	2.07	.....	.....	.....		11.5	758	28.2	81	76	4	Cu	......	bc
			23	12.8	117	12.4	304	.....	.....	.....	.....	.....	.....	.....	12.4	2.37	.....	.....	.....		12.5	759	27.7	82	76	4	Cu	......	bc
			23	13.8	105	13.3	294	.....	.....	.....	.....	.....	.....	.....	13.2	2.45	.....	.....	.....		13.5	759	27.1	86	76	4	Cu	......	bc
			23	14.8	108	14.3	312	.....	.....	.....	.....	.....	.....	.....	14.4	2.35	.....	.....	.....		14.5	758	27.0	83	76	4	Cu	......	bc
			23	15.8	148	15.3	291	.....	.....	.....	.....	.....	.....	.....	15.2	2.92	.....	.....	.....		15.5	758	27.2	87	76	4	Cu-Nb	......	bc
			23	16.8	145	16.2	286	.....	.....	.....	.....	.....	.....	.....	16.2	2.62	.....	.....	.....		16.5	758	27.3	82	76	4	Cu	......	bc
			23	17.8	130	17.4	296	.....	.....	.....	.....	.....	.....	.....	17.3	2.31	.....	.....	.....		17.5	759	27.0	86	76	4	Cu	......	bc
			23	18.8	129	18.3	249	.....	.....	.....	.....	.....	.....	.....	18.3	2.28	.....	.....	.....		18.5	759	26.6	88	76	4	Cu	......	bc
			23	19.8	120	19.3	234	.....	.....	.....	.....	.....	.....	.....	19.2	2.25	.....	.....	.....		19.5	759	26.7	86	76	4	Cu	......	bc
			23	20.8	125	20.3	201	.....	.....	.....	.....	.....	.....	.....	20.3	2.47	.....	.....	.....		20.5	759	26.7	84	87	4	Cu	......	bc
			23	21.8	124	21.2	206	.....	.....	.....	.....	.....	.....	.....	21.2	2.66	.....	.....	.....		21.5	760	26.6	86	76	4	Cu	......	bc
			23	22.8	112	22.2	173	.....	.....	.....	.....	.....	.....	.....	22.2	2.49	.....	.....	.....		22.5	759	26.5	86	65	4	Cu	......	bc
			23	23.8	102	23.3	203	.....	.....	.....	.....	.....	.....	.....	23.3	2.97	.....	.....	.....		23.5	760	26.3	86	65	4	Cu	......	bc
			24	0.8	110	0.2	230	.....	.....	.....	.....	.....	.....	.....	0.2	2.42	.....	.....	.....		0.5	759	26.2	88	65	4	Cu	......	bc
			24	1.8	107	1.3	242	.....	.....	.....	.....	.....	.....	.....	1.3	2.83	.....	.....	.....		1.5	759	26.3	87	65	4	Cu	2	bc
			24	2.8	114	2.2	232	.....	.....	.....	.....	.....	.....	.....	2.2	2.69	.....	.....	.....		2.5	759	26.0	86	65	4	Cu	2	bc
			24	3.8	118	3.2	265	.....	.....	.....	.....	.....	.....	.....	3.2	2.66	.....	.....	.....		3.5	761	26.0	87	65	4	Cu	3	bcq
			24	4.8	108	4.2	373	.....	.....	.....	.....	.....	.....	.....	4.2	2.76	.....	.....	.....		4.5	759	26.0	86	65	4	Cu	3	bc
			24	5.8	115	5.2	367	.....	.....	.....	.....	.....	.....	.....	5.2	2.81	.....	.....	.....		5.5	759	26.0	87	65	4	Cu	4	bc
			24	6.8	143	6.3	291	.....	.....	.....	.....	.....	.....	.....	6.3	2.56	.....	.....	.....		6.5	759	26.0	89	65	4	Cu	......	bc
			24	7.8	150	7.2	268	.....	.....	.....	.....	.....	.....	.....	7.2	2.70	.....	.....	.....		7.5	760	26.6	86	65	4	Cu	......	bc
0.5 N	186.1		25	9.7	143	10.3	362	220	0.78	0.65	1.50	2.05	......	......	11.7	2.98	10.3	0.00	......		10.2	760	28.0	78	65	2	......	......	bc
2.0 N	184.8		26	9.9	139	10.2	374	311	2.01	1.76	3.73	3.94	17.5	5.8	11.5	3.24	11.4	†0.15	9.9		[illegible]	758	27.8	83	42	4	......	......	bc
4.4 N	183.0		27	9.9	156	9.8	368	306	1.07	0.56	2.02	1.27	8.5	2.8	11.6	2.76	10.4	0.00	......		[illegible]	757	28.4	77	65	5	Cu	4	bc
7.4 N	181.8		28	10.1	166	10.9	394	367	1.47	1.55	2.59	2.94	......	......	11.7	2.75	10.3	0.00	......		10.[illegible]	757	28.7	77	65	5	Cu	2	bc
10.3 N	180.5		29	9.4	149	9.4	703	612	1.80	2.04	1.78	2.32	19.1	6.4	11.0	3.21	10.0	0.00	......		9.6	758	28.0	82	66	5	Cu	3	bc
12.8 N	179.2	Jul	1[2]	11.0	131	11.2	569	568	2.22	2.24	2.71	2.74	19.5	6.5	12.1	3.87	11.6	0.00	......		11.2	759	27.2	85	54	2	Cu	3	bcq
15.1 N	176.2		2	8.5	149	8.0	491	.....	.....	.....	.....	.....	.....	.....	7.9	2.16	.....	.....	.....		8.2	762	28.2	85	54	4	Cu	......	bcq
			2	9.5	143	8.9	360	.....	.....	.....	.....	.....	.....	.....	8.8	4.30	.....	.....	.....		9.2	760	28.3	86	54	4	Cu	......	bcqr
			2	10.5	143	9.9	420	.....	.....	.....	.....	.....	.....	.....	9.9	2.96	.....	.....	.....		10.2	760	28.6	77	54	4	Cu	......	bcq
			2	11.5	124	10.9	475	.....	.....	.....	.....	.....	.....	.....	11.0	2.14	.....	.....	.....		11.2	760	28.7	78	54	4	Cu	......	bc
			2	12.5	131	[3]12.0	700	.....	.....	.....	.....	.....	.....	.....	12.9	2.47	.....	.....	.....		12.2	760	29.0	77	54	4	Cu	6	bcr

* Curie $\times10^{-18}$ per cubic centimeter. † Not used in the computation of Q, irregular. [1] Rain squall broke down insulation after first set. [2] Crossed 180th meridian, hence date June 30 dropped. [3] Smoke from galley blowing past ion counter.

15.1 N	176.2	Jul	2	13.5	111	12.9	416								13.0	3.01					13.2	759	28.5	81	54	4	Cu–Nb	10	o
			2	14.5	119	13.9	427								13.9	2.47					14.2	759	28.1	81	54	4	Cu		bc
			2	15.5	124	14.9	460								15.0	2.81					15.2	759	28.1	76	54	4	Cu		bc
			2	16.5	134	15.9	571								15.9	2.91					16.2	758	27.1	81	54	4	Cu		bc
			2	17.5	127	16.9	515								16.9	2.62					17.2	759	27.2	80	54	4	Cu		oq
			2	18.5	131	17.9	797								17.8	1.98					18.2	759	26.9	84	54	4	Cu		bc
			2	19.5	147	18.9	639								18.9	2.47				1.0	19.2	758	26.9	84	54	4	Cu		o
			2	20.5	143	19.9	596								19.8	2.82					20.2	760	27.0	84	54	4	Cu		co
			2	21.5	163	20.9	566								20.9	3.26					[illegible]	759	26.9	84	54	4	Cu		bc
			2	22.5	138	21.9	455								21.9	2.86					[illegible]	759	26.9	84	54	4	Cu		crq
			2	23.6	130	23.2	418								22.9	2.32					23.2	759	26.6	84	54	4	Cu		cq
			2	24.5	153	23.9	353								23.9	2.20					24.2	759	26.6	83	54	4	Cu		cq
			3	1.4	151	0.9	416								0.9	2.86					1.2	759	26.5	87	43	4	Cu	3	bcq
			3	2.5	[1]143																2.2	758	25.5	90	43	4			bcqr
			3	3.4	161	2.8	384								2.8	2.10					3.2	758	25.7	89	54	3			bcqr
16.2 N	172.4		4	9.8	[2]406	10.2			1.13	1.23			89.0	13.0							10.2	760	26.2	89	54	5			oqr
17.2 N	170.4		5	9.8	135	10.2	636	526	1.74	1.63	1.90	2.15	15.2	5.1	11.2	2.54	11.4	†0.11	7.3		10.2	761	31.2	76	53	4	Cu	4	bc
18.2 N	167.7		6	9.2	171	9.3	579	482	0.88	1.07	1.06	1.54	11.1	3.7	10.8	2.98	9.9	1.88	1.9		9.5	761	28.5	76	74	4	Cu	3	bc
19.3 N	165.5		7	9.3	170	10.9	[3]707	245	1.09	0.75	1.07	2.13			10.6	3.41	9.8	0.70	3.4		9.6	762	29.8	76	74	4	Cu	5	bc
20.3 N	163.2		8	10.3	448	10.9	572	365	1.02	1.19	1.24	2.27			12.0	2.54	11.0	†0.24	7.8		10.8	761	27.5	82	96	2	Cu	8	oq
20.5 N	161.3		9	11.0	131	11.0	692	471	1.69	1.66	1.70	2.45	14.6	4.9	12.6	2.26					11.2	761	29.4	78	106	3	Cu	2	bc
19.9 N	159.3		10	8.8	284	8.2	523								8.3	1.88					8.4	761	29.7	72	128	3	Cu		cr
			10	9.7	180	9.2	653								9.3	2.17					9.4	761	30.0	79	128	3	Cu		bc
			10	10.7	174	10.1	602								10.2	2.43					10.4	761	30.2	75	128	3	Cu		bc
			10	11.7	159	11.2	556								11.2	2.52					11.4	761	30.0	72	128	3	Cu		bcq
			10	12.7	[4]100	12.1	538								12.3	2.58					12.4	761	27.9	78	150	3	Cu		bcq
			10	13.7	136	13.2	577								13.2	2.49					13.4	760	29.8	69	139	3	Cu		bc
			10	14.7	135	14.2	628								14.2	2.81					14.4	760	28.7	77	139	3	Cu		bc
			10	15.7	129	15.2	617								15.1	3.05					15.4	760	28.2	77	139	3	Cu		bc
			10	16.7	126	16.2	596								16.2	2.66					16.4	760	28.2	77	139	3	Cu		bc
			10	17.7	112	17.2	607								17.1	2.58					17.4	760	28.3	78	139	3	Cu	8	bc
			10	18.7	120	18.2	607								18.2	2.52					18.4	760	28.1	78	128	3	Cu		bc
			10	19.9	[5]141	19.2	542								19.2	2.82					19.4	762	26.7	85	128	3	Cu		bcqr
			10	20.7	141	20.2	401								20.2	2.91					20.4	762	27.4	80	128	3	Cu		bc
			10	[6]21.7	170	21.0	523								21.1	3.21					21.4	762	27.5	81	128	3	Cu		bc
19.4 N	157.8		11	11.2	165	11.8	568	603							12.4	2.81					11.3	761	32.2	66	128	3	Cu	2	bc
18.6 N	156.1		11	22.5	119	21.9	568								22.0	2.65					22.4	762	27.9	82	139	4	Cu		bc
			11	23.5	82	22.9	528								22.9	3.01					23.4	763	27.9	84	150	4	Cu		bc
			11	24.5	131	23.9	647								23.9	3.02					24.4	763	27.6	84	139	4	Cu		bc
			12	1.5	108	1.0	802								1.0	3.26					1.4	761	27.2	84	139	4	Cu	1	bc
			12	2.5	115	1.9	602								1.9	2.98					2.4	761	27.6	82	139	4	Cu	2	bc
			12	3.5	126	2.9	641								2.9	3.04					3.4	761	27.5	83	139	4	Cu	3	bcq
			12	4.5	118	3.9	726								3.9	3.13					4.4	761	27.5	83	139	4	Cu	1	bc
			12	5.5	123	4.9	635								4.9	3.11					5.4	761	27.5	84	139	4	Cu	3	bc
			12	6.5	139	6.0	808								6.0	2.87					6.4	761	28.2	79	150	4	Cu	3	bc
			12	7.5	138	7.0	597								6.9	2.56					7.4	762	29.4	79	150	4	Cu		bc
17.1 N	153.0		13	10.2	125	11.2	614	515							12.7	2.80	11.5	0.26	6.8		11.4	760	30.5	79	93	4	Cu	3	bc
16.0 N	150.7		14	11.0	196	11.4	521	467							12.7	2.64	11.5	†0.38	6.1		11.4	759	29.8	77	70	4	Ci–Cu	3	bc
14.7 N	148.2		15	11.1	186	12.0	535	494	0.88	0.76	1.14	1.07			13.3	2.70	11.8	0.28	5.1		11.6	757	29.5	78	70	4	Cu	4	bc
14.1 N	146.1		16[7]	10.8	93	11.4	860	716	1.48	1.16	1.19	1.13			12.2	2.70	11.6	0.79	3.0		11.3	757	26.8	90	81	2	Cu	10	oqr
Guam																													
19.5 N	143.6	Aug	12	9.4	144																9.7	752	29.2	78	226	7	Cu–Nb	10	oqr
23.3 N	144.5		13	9.8	180																10.1	753	28.0	78	191	8	Cu–Nb	10	oqr
26.7 N	144.5		14	9.1	128																9.4	758	27.0	89	223	5	Cu–Nb	8	bc
31.9 N	143.6		17	11.1	80																11.3	757	25.3	92	177	4	Nb		oqr
36.1 N	150.1		19	9.8	87																9.9	757	25.3	92	154	7		10	oqr
40.3 N	156.6		21	9.7	158																9.9	764	23.0	94	133	3			qor

† Not used in the computation of Q, irregular. [1] Stopped raining just before this set. [2] Potential gradient gradually increased as heavy squall approached, fibers of electroscope finally going off scale. [3] Burning paint to windward of atmospheric-electric house. [4] Heavy squall passed just ahead. [5] Rain squall just over. [6] Observations suspended, to be resumed 24 hours later, due to failure of ion counter. [7] 150 miles from Guam.

FINAL RESULTS OF OCEAN ATMOSPHERIC-ELECTRIC OBSERVATIONS ON THE CARNEGIE, 1915–1921—*Continued.*

CRUISE IV, PACIFIC OCEAN, 1916–1917—*Continued.*

Lat.	Long. E. of Gr.	Date	Potential gradient L.M.T.	Potential gradient P	Ionic content L.M.T.	Ionic content n_+	Ionic content n_-	Conductivity λ_+	Conductivity λ_-	Ionic mobility k_+	Ionic mobility k_-	Current-density, i	Current-density, i	Penetrating radiation L.M.T.	Penetrating radiation R	Radioactive content Ionization L.M.T.	Radioactive content Ionization q_0	Radioactive content Ionization ΔT	Radioactive content Q	Meteorological data L.M.T.	Pressure	Temp. Cent.	Rel. hm.	Wind True dir.	Wind Force	Clouds Kind	Clouds Am't	Weather
°	°	1916	h	(v/m)	h	(ions/cc)		(ESU×10⁻⁴)		(cm/s / v/cm)		(ESU× 10⁻⁷)	(a×10⁻¹⁶ / cm²)	h	(ions/cc / s)	h	(ions/cc / s)	m	*	h	mm	°	p.d.	°				
42.7 N	158.3	Aug 22	9.4	143	12.1			1.96	1.54					13.0	3.15					9.7	767	17.8	88	156	4	Cu-Nb	9	cm
44.8 N	159.2	23	9.9	223	10.7	655	467	1.11	0.80	1.18	1.19			11.9	3.61	11.0	2.01	5.2		10.7	766	17.5	72	111	3	Cu	3	bc
46.4 N	160.3	24	8.6	[1]386	[1]9.2	397	288	0.36	0.10	0.63	0.24									8.8	761	16.8	78	134	1	Cu-Nb	8	cq
46.9 N	163.0	25	10.5	165	11.3	1030	706	0.23	0.35	0.16	0.34			13.9	2.39	11.6	12.13	2.1		10.8	755	15.6	85	281	2			bcfm
47.4 N	169.0	28	8.3	178	8.8	955	469	0.34	0.17	0.25	0.25	3.0	1.0	9.6	2.86					8.6	757	13.2	89		0	Cu-Nb	4	bc
47.8 N	171.1	29	9.0	185	8.4	714								8.5	2.50					8.6	755	12.6	96	173	2		10	o
		29	9.9	134	9.4	653								9.4	3.30					9.6	754	12.4	98	162	3		10	o
		29	10.9	93	10.4	669								10.3	2.65					10.6	754	12.4	97	162	4	Cu-Nb, Ci-St	10	o
		29			11.4	697								11.3	2.41					11.6	754	12.4	94	173	4	Cu-Nb, Ci-St	10	or
48.3 N	174.9	30	10.0	177																10.2	755	12.0	93	230	5	Cu-Nb	10	omr
48.9 N	180.1	30[2]	11.9	208	11.9	265	357	0.58	0.58	1.52	1.13	8.0	2.7	12.6	3.40					12.0	759	10.5	98	256	4		10	ormf
49.5 N	182.2	31	12.3	224	11.0	460	374	0.50	0.38	0.76	0.71			14.4	1.73	12.1	16.19	1.8		11.9	761	12.3	91	258	2	Ci	8	bc
49.9 N	184.2	Sep 1	11.0	[3]53	11.7	676	469	1.19	1.12	1.22	1.66			12.3	3.01	11.6	14.31	3.0		11.3	768	9.5	94	236	2	Cu-Nb	10	o
51.0 N	187.5	2	12.1	170																12.3	760	9.0	99	136	4	Cu-Nb	10	omr
51.5 N	192.0	3	10.6	194	11.5	900	919									11.5	2.82	4.0		10.8	760	8.9	95	296	5	Ci-Cu	8	bcm
52.1 N	197.0	4	8.8	266	8.3	846														8.5	768	10.1	83	332	3	Cu-Nb	10	o
		4	9.8	190	9.3	858														9.5	768	9.6	83	332	3	Ci-St, Cu-Nb	10	o
		4	10.8	125	10.4	807														10.5	766	9.4	80	332	3	Ci-St	10	o
		4	11.8	89	11.3	818	644													11.5	766	9.9	83	332	3	Ci-St	10	o
		4	12.8	109	12.3	791														12.5	766	9.8	78	332	2	Ci-St		
		4	13.8	84	13.3	952														13.5	766	9.2	77	309	2			
		4	14.8	99	14.3	778														14.5	766	9.5	80	264	2			
		4	15.8	130	15.3	630														15.5	766	9.2	78	275	2			
		4	16.8	144	16.3	690														16.5	766	8.8	84	275	2			
		4	17.8	131	17.3	778														17.5	766	8.5	82	287	2			
		4	18.8	112	18.3	777														18.5	765	8.4	82	287	2			
		4	19.8	102	19.3	647														19.5	766	8.3	82	287	2			
		4	20.8	102	20.3	655														20.5	765	8.3	83	264	2			
		4	21.8	94	21.3	619														21.5	765	8.4	83	287	2			
		4	22.8	105	22.3	590														22.5	765	8.2	85	287	3			
		4	23.8	98	23.3	687														23.5	765	8.2	84	287	3			
		5	0.8	109	0.3	759														0.5	765	8.2	85	309	3			
		5	1.8	58	1.2	713														1.5	765	8.0	87	264	4			om
		5	2.8	64	2.2	606														2.5	765	8.0	86	309	4			om
		5	3.8	88	3.1	709														3.5	765	8.0	86	287	4			om
		5	4.8	100	4.2	613													12.9	4.5	765	8.1	87	309	4			om
		5	5.7	100	5.1	594														5.5	764	8.0	92	287	4			omw
		5	6.8	118	6.3	862														6.5	763	8.3	79	333	4			o
		5	7.8	139	7.2	848														7.5	764	8.3	86	333	4			or
53.4 N	203.7	6	9.5	107	8.9	689	465													9.7	761	9.0	88	290	4	Cu	10	om
52.9 N	208.6	7	11.9	207	12.2	628	433	1.75	1.17	1.94	1.88	20.1	6.7	13.1	2.45					12.1	759	10.6	87	224	3	Cu-Nb	10	omwr
49.7 N	215.7	9	10.6	[4]97	10.7			1.82	2.00			12.4	4.1	11.6	2.00					10.7	768	13.2	97	226	4			omf

*Curie×10⁻¹⁸ per cubic centimeter.   [1] Small engine running; smoke and gas all around vessel.   [2] Crossed 180th meridian, hence date August 30 repeated.   [3] Fog just cleared away.   [4] Observations cut short by fine mist and fog spoiling insulation.

47.3 N	218.7	Sep	10	10.5	357	12.0	213	68											10.8	772	14.8	96	225	4			bcmfw
45.5 N	220.6		11	13.0	185	12.0	818	598	1.21	0.66	1.03	0.77	11.5	3.8					12.1	772	16.1	91	337	2			comf
43.4 N	221.7		12	11.2	188	11.5	665	489								11.8	4.83	2.6	11.7	773	16.5	81	77	4	Cu-Nb	10	o
41.2 N	221.7		13	10.8	182	11.2	545	325	0.99	0.62	1.26	1.33	9.8	3.3		11.4	5.75	3.1	11.2	771	18.0	80	88	5	Cu-Nb	8	bc
40.9 N	221.8		14	8.7	181	8.4	711		1.32		1.29								8.4	768	17.8	69	76	2	Ci-St	10	o
			14	9.7	157	9.2	711		1.35		1.31								9.4	767	17.0	75	76	2	Ci-St		oo
			14	10.7	127	10.2	680		1.43		1.46								10.4	767	16.8	78	65	2	Ci-St	10	o
			14	11.7	151	11.2	537		1.15		1.49								11.4	767	17.8	73		0	Ci-St	9	o
			14	12.7	162	12.3	651		1.09		1.16								12.4	767	18.0	73		0	Ci-St	9	o
			14	13.7	174	13.2	695		1.27		1.27								13.4	767	17.9	72	76	1	Ci-St, Cu	6	bc
			14	14.7	161	14.2	676		1.31		1.35								14.4	766	17.8	73	76	1	Ci-Cu, St		bc
			14	15.7	135	15.2	607		1.25		1.43								15.4	765	17.3	76	76	1	Cu, St		o
			14	16.7	127	16.3	662		1.34		1.41								16.4	766	17.1	74		0			o
			14	17.7	93	17.2	504		1.03		1.42								17.4	766	16.8	74		0	Cu, St		o
			14	18.7	86	18.2	644		1.17		1.26								18.4	767	16.5	78		0	Cu	10	o
			14	19.7	100	19.2	662		1.36		1.43								19.4	767	16.3	73	65	1	Cu, St	10	o
			14	20.7	108	20.3	676		1.15		1.18								20.4	766	16.3	67		0	Cu, St	10	o
			14	21.7	90	21.3	677		1.11		1.14								21.4	766	16.4	79		0	Cu, St	10	o
			14	22.7	103	22.2	718		1.31		1.27								22.4	766	16.2	79		0	Cu, St	10	o
			14	23.7	126	23.3	655		1.23		1.31								23.4	766	16.2	72		0	Cu, St	10	o
			15	0.7	138	0.2	676		1.38		1.42								0.4	765	16.3	71		0	Cu, St	10	o
			15	1.7	115	1.2	601		1.20		1.39								1.4	765	16.2	74		0	Cu, St	10	o
			15	2.7	153	2.3	545		1.37		1.75								2.4	765	16.1	74		0	Cu	10	o
			15	3.7	112	3.2	687		1.36		1.38								3.4	765	16.5	76		0	Cu	10	o
			15	4.7	126	4.2	483		1.17		1.68								4.4	765	16.5	77		0	Cu	10	o
			15	5.7	155	5.2	664		1.30		1.36								5.4	765	16.5	73		0	Cu	10	o
			15	6.7	140	6.3	501		1.22		1.44								6.4	764	16.5	68		0	Cu	10	o
			15	7.7	146	7.3	759		1.31		1.20								7.4	766	17.0	77	188	1	Cu	10	o
40.7 N	224.6		16	9.9	143	10.3	817	590	1.20	0.98	1.02	1.15	10.4	3.5		10.4	10.02	2.2	10.2	765	18.5	82	177	4	Cu	8	bc
40.2 N	228.8		17	11.4	115														11.6	764	17.8	93	201	3	Cu-Nb	8	r
39.5 N	230.6		18	11.2	156	11.4	600	466	1.26	0.94	1.46	1.40	11.4	3.8		11.7	2.61	4.3	11.5	768	16.8	83	42	4	Cu	10	o
38.6 N	234.2		19	11.5	[1]203	12.5	247	263	0.63	0.54	1.78	1.43							11.8	764	15.0	93	19	4	Cu-Nb	10	owd
38.3 N	235.5		20	12.0	544	12.2	403	183	0.43	0.54	0.74	2.04	17.9	6.0					12.2	763	15.0	89	334	1		10	ofm
San Francisco																											
35.9 N	236.7	Nov	2	11.6	174														11.8	766	14.0	86	287	1	Ci	1	bs
35.3 N	236.0		3	10.4	180	11.3			2.01	1.20									10.1	765	15.3	94	231	2	Cu-St	3	bcs
34.2 N	236.4		4	9.6	161	9.9	965	618	1.71	1.05	1.23	1.18	14.8	4.9					10.1	764	15.2	90	241	2	Nb	9	cos
31.8 N	237.1		5	10.4	131	10.9	933	589	1.87	1.73	1.40	2.04	15.7	5.2					10.7	768	16.0	73	285	4	Cu	7	bcs
29.4 N	238.3		6	11.5	177	11.7	678	588	1.52	1.41	1.56	1.67	17.3	5.8					11.8	768	16.8	71	352	4	Cu	3	bcs
26.8 N	240.0		7	10.8	255	11.3	597	439	1.32	0.96	1.54	1.52	19.4	6.5					11.0	766	17.2	71	35	4	Ci, Cu	9	cs
23.8 N	241.7		8	11.1	200	11.7	628	327	1.26	0.82	1.39	1.74							11.4	764	18.0	79	57	5	A-Cu	1	bcs
20.7 N	243.4		9	8.6	165	8.2	625												8.3	763	20.2	75	56	4	Cu	2	bv
			9	9.6	184	9.1	556												9.3	762	20.6	75	56	4			bc
			9	10.6	188	10.1	454												10.3	762	19.6	77	56	3		0	b
			9	11.6	180														11.3	762	19.5	75	56	3		0	b
			9	12.6	161	12.3	780												12.3	762	19.7	75	56	3		0	b
			9	13.6	216	13.2	545												13.3	762	20.2	74	56	2		0	b
			9	14.6	177	14.1	533												14.3	760	21.2	72	56	1		0	b
			9	15.6	143	15.2	782												15.3	760	21.3	69	56	1		0	b
			9	16.6	182	16.2	466												16.3	759	20.7	75	56	1		0	b
			9	17.6	135	17.1	428												17.3	760	20.0	72	56	1		0	b
			9	18.6	123	18.1	478												18.3	760	19.6	74	56	1		0	b
			9	19.6	131	19.2	531												19.3	760	19.6	79	56	1		0	b
			9	20.6	134	20.1	558												20.3	760	19.4	78	56	1		0	b
			9	21.6	167	21.1	416												21.3	760	19.4	77	56	1	Cu	1	b
			9	22.6	126	22.2	425												22.3	760	19.4	79	56	1	Cu	2	bc

[1] About 100 miles from the coast of California.

FINAL RESULTS OF OCEAN ATMOSPHERIC-ELECTRIC OBSERVATIONS ON THE CARNEGIE, 1915–1921—*Continued.*

CRUISE IV, PACIFIC OCEAN, 1916–1917—*Continued.*

Lat.	Long. E. of Gr.	Date	Potential gradient L. M. T.	Potential gradient P	Ionic content L. M. T.	Ionic content n_+	Ionic content n_-	Conductivity λ_+	Conductivity λ_-	Ionic mobility k_+	Ionic mobility k_-	Current-density, i	Current-density, i	Penetrating radiation L. M. T.	Penetrating radiation R	Radioactive content, Ionization L. M. T.	Ionization q_0	Ionization ΔT	Q	Meteorological data L. M. T.	Pressure	Temp. Cent.	Rel. hm.	Wind True dir.	Wind Force	Clouds Kind	Clouds Am't	Weather
°	°	*1916*	h	$\left(\frac{v}{m}\right)$	h	$\left(\frac{ions}{cc}\right)$		(ESU×10^{-4})		$\left(\frac{cm/s}{v/cm}\right)$		(ESU× 10^{-7})	$\left(\frac{a\times10^{-16}}{cm^2}\right)$	h	$\left(\frac{ions/cc}{s}\right)$	h	$\left(\frac{ions/cc}{s}\right)$	m	*	h	mm	°	p. ct.	°				
20.7 N	243.4	Nov 9	23.6	153	23.1	483	...	...	...	...	...	...	...	...	...	...	...	...	...	23.3	760	19.4	80	56	1	Cu	3	bc
		10	0.6	157	0.1	467	...	...	...	...	...	...	...	...	...	...	...	...	...	0.3	759	19.4	80	56	1	Cu	5	bc
		10	1.6	147	1.1	389	...	...	...	...	...	...	...	...	...	...	...	...	...	1.3	760	19.2	80	56	1	A-Cu	6	bc
		10	2.6	177	2.1	357	...	...	...	...	...	...	...	...	...	...	...	...	...	2.3	760	19.2	81	56	1	A-Cu	8	c
		10	3.6	196	3.0	420	...	...	...	...	...	...	...	...	...	...	...	...	...	3.3	760	18.9	80	56	1	Cu	7	bc
		10	4.6	217	4.0	388	...	...	...	...	...	...	...	...	...	...	...	...	...	4.3	760	19.2	79	56	1	Ci	10	o
		10	5.6	234	5.0	378	...	...	...	...	...	...	...	...	...	...	...	...	...	5.3	760	19.0	80	56	1	Ci, St-Cu	10	o
		10	6.6	215	6.2	320	...	...	...	...	...	...	...	...	...	...	...	...	...	6.3	760	19.2	82	56	1	Ci-Cu	8	bc
		10	7.6	259	7.1	435	...	...	...	...	...	...	...	...	...	...	...	...	...	7.3	761	20.0	78	56	1	Ci-Cu	7	bc
18.7 N	244.4	12	11.2	166	11.9	365	330	1.01	0.85	1.92	1.79	...	...	14.5	2.48	...	...	...	...	11.4	763	22.8	74	348	3	Cu	...	bc
16.8 N	244.6	13	11.0	169	11.5	365	339	0.80	0.72	1.52	1.48	8.5	2.8	13.3	2.95	11.5	4.25	2.2		11.4	762	23.1	78	348	3	Nb	10	o
15.0 N	244.9	14	10.7	118	11.5	...	...	0.59	0.48	...	...	...	...	...	...	11.5	†3.29	11.0		11.1	760	24.7	71	325	2	A-Cu	10	o
12.3 N	244.9	16	11.2	157	11.5	418	301	1.39	1.12	2.31	2.59	13.1	4.4	13.4	2.40	11.8	4.48	2.8		11.6	762	25.7	77	64	4	...	...	bcz
9.4 N	246.5	17	8.6	180	8.2	435	...	...	...	...	...	...	...	...	...	...	...	...		8.3	763	26.8	88	54	5	Cu-Nb	7	bc
		17	9.6	172	9.3	384	...	...	...	...	...	...	...	...	...	...	...	...		9.3	760	26.9	82	54	5	Cu	3	bc
		17	10.6	233	10.1	352	...	...	...	...	...	...	...	...	...	...	...	...		10.3	760	26.7	83	54	6	Cu-Nb	9	cqo
		17	11.6	176	11.2	445	...	...	...	...	...	...	...	...	...	...	...	...		11.3	758	25.4	88	65	6	Cu	3	bc
		17	12.6	150	12.1	426	...	...	...	...	...	...	...	...	...	...	...	...		12.3	760	26.0	88	54	5	Cu-Nb	7	bc
		17	13.7	129	13.1	416	...	...	...	...	...	...	...	...	...	...	...	...		13.3	760	25.6	90	54	4	Cu-Nb	9	cqr
		17	[1]15.6	146	15.2	515	...	...	...	...	...	...	...	...	...	...	...	...		15.3	761	26.3	91	65	4	...	...	...
		17	16.6	125	16.1	539	...	...	...	...	...	...	...	...	...	...	...	...	8.4	16.3	761	25.3	90	65	4	Ci	9	r
		17	[2]17.6	130	17.2	450	...	...	...	...	...	...	...	...	...	...	...	...		17.3	757	26.2	87	65	3	...	...	...
8.8 N	246.6	18	11.7	145	11.9	561	515	2.17	1.66	2.69	2.24	18.5	6.2	12.6	2.41	...	...	...		11.9	760	26.1	82	178	3	...	...	o
		18	[3]18.5	91	18.0	262	...	...	...	...	...	...	...	...	...	...	...	...		18.3	759	25.2	93	178	1	Cu-Nb	9	oqr
7.8 N	248.6	20	11.7	148	...	...	...	...	...	...	...	...	...	...	...	...	...	...		11.9	760	26.8	81	223	2	...	...	bcz
7.6 N	249.3	21	11.2	148	11.2	...	...	0.85	...	...	...	...	...	...	...	...	...	...		11.4	762	26.0	82	189	5	...	...	oqr
7.6 N	250.4	22	11.0	140	10.5	482	242	0.80	0.76	1.15	2.18	7.3	2.4	13.0	2.22	...	...	...		12.0	761	26.4	77	189	3	St-Cu	9	oz
7.0 N	251.0	24	10.9	108	10.6	...	333	...	1.01	...	2.11	...	...	...	...	...	...	...		11.9	759	24.6	82	189	4	St-Cu, Nb	10	oq
6.9 N	253.0	25	[4]10.7	133	10.7	660	488	1.57	1.45	1.65	2.07	13.7	4.6	12.9	1.46	...	...	...		11.0	760	25.4	83	189	1	Nb	10	oq
5.5 N	252.0	27	10.6	164	10.8	628	480	[5]1.38	0.87	1.54	1.26	12.3	4.1	12.0	4.30	11.3	5.02	2.2		11.2	759	25.2	81	177	4	A-Cu	5	bcz
5.1 N	249.5	28	10.8	94	10.8	...	667	...	...	...	...	...	...	...	...	...	...	...	...	11.1	759	23.5	86	166	4	...	...	ord
3.4 N	246.0	29	8.5	149	8.1	568	...	...	...	...	...	...	...	8.0	3.05	...	...	...	...	8.2	761	25.6	78	144	4	St-Cu	5	bc
		29	9.5	148	9.1	542	...	...	...	...	...	...	...	9.0	2.92	...	...	...	...	9.3	761	25.7	80	144	4	Cu	4	bc
		29	10.5	130	10.1	550	...	...	...	...	...	...	...	10.1	4.79	...	...	...	...	10.2	762	24.0	88	144	4	Cu-Nb	9	cr
		29	11.5	164	11.0	513	...	...	...	...	...	...	...	10.9	3.21	...	...	...	...	11.2	757	25.2	84	144	5	Cu-Nb	7	bc
		29	12.5	150	12.0	504	...	...	...	...	...	...	...	11.9	4.13	...	...	...	...	12.2	757	25.2	76	144	5	A-Cu	7	bc
		29	13.5	145	13.0	550	...	...	...	...	...	...	...	13.0	3.99	...	...	...	...	13.2	756	25.0	81	144	5	Cu	3	bc
		29	14.5	149	14.0	535	...	...	...	...	...	...	...	14.0	4.04	...	...	...	...	14.2	755	24.3	87	144	5	Ci-Cu	7	bc
		29	15.5	124	15.0	518	...	...	...	...	...	...	...	15.0	2.78	...	...	...	...	15.2	755	23.9	89	144	5	Ci-Cu	9	o
		29	16.5	118	16.0	474	...	...	...	...	...	...	...	16.1	2.85	...	...	...	...	16.2	755	23.6	88	144	5	Ci-Cu	9	o
		29	17.5	94	17.0	400	...	...	...	...	...	...	...	17.0	3.11	...	...	...	...	17.2	759	23.2	88	144	5	...	10	or
		29	18.5	84	18.0	433	...	...	...	...	...	...	...	18.0	2.92	...	...	...	...	18.2	757	22.7	88	144	5	...	10	or

* Curie×10^{-8} per cubic centimeter. † Not used in the computation of Q, irregular. [1] Rain from 14h to 15h. [2] Rain stopped the observations at 18h; resumed 24 hours later. [3] Rain again interrupted observations. [4] Rain before and after this set. [5] Lower guard ring removed before these observations.

3.4 N	246.0	Nov	29	19.5	112	19.0	442								19.0	2.48					19.2	757	22.8	86	144	5	Ci, Nb	10	o
			29	20.5	114	20.2	391								20.0	2.92					20.2	758	22.2	90	144	5	Ci	10	d
			29	21.5	99	21.0	438								20.9	4.47					21.2	758	22.2	87	144	5	Ci	10	o
			29	22.5	82	22.0	420								22.1	3.61					22.2	758	22.2	87	144	5	Ci	10	os
			29	23.5	78	23.1	442								23.1	3.05					23.2	758	22.4	87	144	5	Ci, Nb	10	r
			29	24.6	109	24.0	442								23.9	2.92					24.2	758	22.0	85	144	5			ro
			30	1.6	157	1.1	416								0.9	2.98					1.2	757	22.3	84	144	5			os
			30	2.5	138	2.1	381								2.0	3.18					2.2	757	22.1	85	144	5			os
			30	3.5	153	3.1	392								2.9	3.26					3.2	756	22.0	86	144	5	Nb	3	bcs
			30	4.5	169	4.1	409								3.9	2.69					4.2	757	21.7	88	144	5	Nb	2	bc
			30	5.5	191	5.1	379								5.0	2.48					5.2	756	21.4	85	144	6	St-Cu	1	b
			30	6.5	188	6.0	374								6.0	2.72					6.2	758	21.6	88	144	6	Fr-Cu	3	bc
			30	7.5	196	7.0	394								7.0	2.75					7.2	759	21.9	89	144	6	Cu-Nb	7	co
0.2 S	241.5	Dec	1	10.3	236	10.6	282	115	1.48	0.89	3.65	5.39	18.6	6.1	11.8	3.09	11.0	0.00			10.8	761	21.2	91	109	2			o
1.4 S	240.8		2	10.6	205	10.7	480	232	1.13	0.84	1.64	2.52	13.5	4.5	12.2	3.04	11.2	0.71	4.5		10.9	762	23.0	85	98	1	St	1	bs
2.2 S	240.0		3	9.8	159	10.2	416	270	0.95	0.53	1.59	1.37	7.8	2.6	11.9	2.77	10.4	0.69	4.4		10.2	762	23.5	86	109	1	Ci-Cu	8	bc
4.2 S	239.2		4	10.4	174	11.0	504	277	1.19	0.97	1.64	2.43			11.7	2.82	11.1	0.00			10.8	762	22.9	86	121	4	A-Cu	9	cs
6.7 S	237.1		5	10.2	164	10.4	365	277	1.21	0.89	2.31	2.23	11.5	3.8	11.6	2.68	10.9	†1.07	3.6		10.4	763	24.8	75	133	5	Ci	1	bs
9.5 S	235.1		6	10.3	180	10.9	304	247	1.23	0.93	2.81	2.62					11.1	†0.18	15.5		10.7	763	26.1	72	110	5	A-Cu	2	bcv
13.7 S	234.4		7	8.7	51	8.2	446														8.4	765	24.0	86	100	5	Cu-Nb	9	o
			7	9.7	53	9.2	458														9.4	766	23.8	86	100	5	Cu-Nb	9	or
			7	10.7	155	10.2	539														10.4	765	24.3	86	100	5	Cu-Nb	9	bco
			7	11.7	167	11.2	490														11.4	761	25.0	82	77	4	A-Cu	8	bc
			7	12.7	171	12.2	496								12.2	2.98					12.4	760	25.8	83	100	4	A-Cu	7	bc
			7	13.7	162	13.1	560								13.2	3.06					13.4	760	26.0	76	100	4	Fr-Cu	7	bc
			7	14.7	170	14.2	463								14.2	3.15					14.4	759	24.8	80	122	4	Cu	5	bc
			7	15.7	133	15.2	451								15.2	3.06					15.4	759	24.4	84	100	4	Cu	4	bc
			7	16.7	145	16.2	389								16.1	3.13					16.4	759	24.5	84	100	5	Cu	3	bc
			7	17.7	140	17.2	385								17.2	3.13					17.4	759	24.7	80	111	5	Ci	1	bc
			7	18.7	149	18.2	319								18.2	3.43					18.4	760	24.2	77	111	5	St-Cu	1	bc
			7	19.7	134	19.2	351								19.1	3.05					19.4	759	24.1	85	111	5	Cu	3	bc
			7	20.7	130	20.2	357								20.2	2.95					20.4	760	24.2	84	111	5	Cu	3	bc
			7	21.7	122	21.2	339								21.2	3.15					21.4	761	24.4	78	100	5	Cu-Nb	4	bc
			7	22.7	130	22.2	367								22.1	3.06					22.4	761	24.1	79	100	5	Cu	4	bc
			7	23.7	134	23.2	346								23.2	3.15					23.4	761	24.0	79			Ci	4	bc
			8	0.7	162	0.2	353								0.2	3.43					0.4	759	24.2	79			Cu	1	bs
			8	1.7	145	1.3	440								1.3	3.74					1.4	759	24.0	80			Cu	1	bcs
			8	2.7	153																2.4	759	24.0	75			Cu	2	bcs
			8	3.7	167	3.2	486								3.2	3.35					3.4	759	23.9	77			Cu	2	bcs
			8	4.7	174	4.3	416								4.2	2.98					4.4	759	24.0	75			Cu	2	bcs
			8	5.7	166	5.2	379								5.1	2.83					5.4	760	24.1	76			Cu	2	bcs
			8	6.7	165	6.2	432								6.1	3.22					6.4	760	24.8	76			Cu	2	bs
			8	7.7	166	7.1	437								7.1	2.50					7.4	760	24.8	81			Cu	2	bs
17.7 S	234.0		9	10.5	179	11.3	483	353	1.47	1.23	2.12	2.42			12.4	2.50					11.5	762	24.8	81	101	4	Cu-Nb	7	bcr
20.1 S	233.4		10	9.7	192	9.8	551	352	1.32	0.89	1.67	1.76	14.1	4.7	11.9	2.49	10.4	0.73	2.8		11.4	763	26.8	70	124	3	St-Cu		bcs
22.2 S	233.5		11	10.6	210	9.9	522	340	1.30	0.89	1.73	1.77			11.8	3.04	10.5	†0.14	11.2	0.5	10.8	764	26.3	72	101	3	A-Cu	2	bcv
24.6 S	234.0		12	10.4	171	11.2	497	369	1.32	0.95	1.85	1.79			12.5	2.54	11.7	0.17	6.3		10.7	765	25.8	74	80	4	Cu	1–2	bcs
26.4 S	235.5		13	11.1	190	11.3	550	350	1.34	0.99	1.69	1.97	14.8	4.9							11.4	765	26.5	69	35	3	Ci-St	9	cs
27.3 S	236.7		14	10.2	160	10.4	612	432	1.33	1.04	1.51	1.67	13.4	4.5	11.1	3.15					10.4	767	26.3	70	35	1	A-Cu	1–2	bc
28.2 S	237.8		15	8.7	151	8.3	577								8.3	2.55					8.4	770	25.0	76		0	Cu	1	b
			15	9.7	135	9.2	596								9.2	2.78					9.4	768	25.6	75	13	1	Cu	1	b
			15	10.7	153	10.2	594								10.2	2.73					10.4	768	26.2	76	13	1	Cu	3	bc
			15	11.7	127	11.1	584								11.1	2.74					11.4	768	25.8	76	13	1	Cu	2	bc
			15	12.7	140	12.3	504								12.1	2.84					12.4	768	25.2	66	13	1	Cu	1	b
			15	13.7	127	13.2	491								13.2	3.01					13.4	767	27.3	71	13	1	Cu	2	b
			15	14.7	124	14.3	584								14.3	2.52					14.4	767	26.7	69	283	1	Cu	2	b

†Not used in the computation of Q, irregular. [1] Rain during middle of observations.

FINAL RESULTS OF OCEAN ATMOSPHERIC-ELECTRIC OBSERVATIONS ON THE CARNEGIE, 1915–1921—*Continued.*

CRUISE IV, PACIFIC OCEAN, 1916–1917—*Continued.*

Lat.	Long. E. of Gr.	Date	Potential gradient L.M.T.	Potential gradient P	L.M.T.	Ionic content n_+	Ionic content n_-	Conductivity λ_+	Conductivity λ_-	Ionic mobility k_+	Ionic mobility k_-	Current-density, i	Current-density, i	Penetrating radiation L.M.T.	Penetrating radiation R	Radioactive content L.M.T.	Radioactive content Ionization q_0	Radioactive content Ionization ΔT	Radioactive content Q	Meteorological data L.M.T.	Pressure	Temp. Cent.	Rel. hm.	Wind True dir.	Wind Force	Clouds Kind	Clouds Am't	Weather
°	°	*1916*	h	$\left(\frac{v}{m}\right)$	h	$\left(\frac{ions}{cc}\right)$		($ESU\times10^{-4}$)		$\left(\frac{cm/s}{v/cm}\right)$		($ESU\times10^{-7}$)	$\left(\frac{a\times10^{-16}}{cm^2}\right)$	h	$\left(\frac{ions/cc}{s}\right)$	h	$\left(\frac{ions/cc}{s}\right)$	m	*	h	mm	°	p. ct.	°				
28.2 S	237.8	Dec 15	15.7	116	15.2	623	....	....	....	....	....	....	....	15.1	2.43	....	....	....		15.4	767	27.0	62	283	1	Cu	....	b
		15	16.7	130	16.3	583	....	....	....	....	....	....	....	16.2	2.65	....	....	....		16.4	767	28.0	69	283	1	Ci	3	bc
		15	17.7	89	17.2	520	....	....	....	....	....	....	....	17.2	2.66	....	....	....		17.4	767	25.2	73	283	1	Ci-Cu	4	....
		15	18.7	80	18.3	556	....	....	....	....	....	....	....	18.2	2.66	....	....	....		18.4	767	24.3	73	283	1	Ci-Cu	2	bc
		15	19.7	86	19.2	660	....	....	....	....	....	....	....	19.2	3.28	....	....	....		19.4	767	24.1	75	283	1	Ci-Cu	4	bc
		15	20.7	73	20.2	802	....	....	....	....	....	....	....	20.1	2.65	....	....	....		20.4	767	24.0	75	283	1	Ci-Cu	4	bc
		15	21.7	80	21.2	596	....	....	....	....	....	....	....	21.1	2.70	....	....	....		21.4	767	24.0	80	328	1	Ci-Cu	2	bc
		15	22.7	76	22.2	664	....	....	....	....	....	....	....	22.2	2.85	....	....	....		22.4	767	23.9	70	328	1	Ci-Cu	2	bc
		15	23.7	81	23.2	617	....	....	....	....	....	....	....	23.1	2.89	....	....	....		23.4	768	23.8	84	328	1	Ci-Cu	3	bc
		16	0.7	85	0.2	571	....	....	....	....	....	....	....	0.2	3.00	....	....	....		0.4	767	23.6	83	329	3	Ci-Cu	3	bc
		16	1.7	94	1.4	539	....	....	....	....	....	....	....	1.3	2.82	....	....	....		1.4	767	23.4	75	329	3	A-Cu	2	bc
		16	2.7	90	2.2	487	....	....	....	....	....	....	....	2.2	2.92	....	....	....		2.4	766	23.4	77	329	3	A-Cu	3	bc
		16	3.7	93	3.2	539	....	....	....	....	....	....	....	3.2	2.75	....	....	....		3.4	766	23.3	75	329	3	A-Cu	3	....
		16	4.7	111	4.1	539	....	....	....	....	....	....	....	4.1	2.92	....	....	....		4.4	766	23.3	75	329	3	Cu-Nb	3	bc
		16	5.7	77	5.1	533	....	....	....	....	....	....	....	5.2	2.66	....	....	....		5.4	767	23.3	80	....	4	Cu-Nb	5	bcr
		16	6.8	[1]147	6.5	491	....	....	....	....	....	....	....	6.4	2.94	....	....	....		6.4	769	22.9	84	....	2	Cu-Nb	5	r
		16	7.7	117	7.3	496	....	....	....	....	....	....	....	7.3	3.11	....	....	....		7.4	768	24.2	80	....	3	Cu-Nb	5	bc
30.4 S	240.2	17	10.4	153	10.8	563	442	1.16	0.93	1.43	1.46	10.7	3.6	12.3	2.69	....	....	....		10.7	765	23.4	86	....	....	Ci-Cu	7	bcz
31.8 S	242.7	18	11.4	149	11.5	499	476	0.97	0.86	1.35	1.26	9.1	3.0	12.5	2.87	....	....	....		11.6	764	23.0	84	306	3	Ci-St	10	oz
32.1 S	245.3	19	10.5	157	10.8	491	486	1.38	1.25	1.95	1.79	13.8	4.6	12.2	2.92	11.6	0.00	....		10.8	764	22.6	79	240	4	Ci-Cu	2	bc
32.4 S	248.1	20	11.7	125	11.8	528	290	1.58	1.30	2.08	3.12	12.0	4.0	....	....	....	....	....		12.2	766	23.1	86	331	5	St	6	bcz
31.1 S	250.9	21	11.5	124	11.9	....	....	1.62	1.30	....	....	12.1	4.0	....	....	....	....	....		12.0	768	25.6	74	320	3	Cu	2	bcv
30.5 S	251.1	22	11.2	135	11.6	....	....	1.32	1.04	....	....	10.6	3.5	13.2	3.01	11.8	0.55	3.7		11.6	770	25.7	76	50	1	A-Cu	1	bv
30.4 S	251.5	23	[2]10.5	149	10.9	....	....	1.65	1.29	....	....	14.6	4.9	11.6	2.76	11.0	†0.65	2.7	....	10.6	773	24.0	82	95	3	Cu, Cu-Nb	8	bc
Easter Island		*1917*																										
26.9 S	250.4	Jan 2[3]	10.7	120	10.7	455	356	1.71	1.49	2.61	2.91	12.8	4.3	12.2	3.43	11.4	0.39	5.1		11.2	769	25.8	68	58	3	Cu	0–1	b
24.5 S	249.1	3	10.4	141	10.5	....	....	1.72	1.30	....	....	14.2	4.7	11.8	3.14	11.0	0.53	4.8		10.8	768	24.7	71	69	5	Ci-St	8	cz
21.6 S	248.9	4	10.5	133	10.9	868	483	1.72	1.46	1.38	2.10	14.1	4.7	12.2	5.08	11.2	2.42	5.7		11.1	772	21.4	74	90	5	Ci	3	bcz
18.4 S	248.6	5	11.0	119	11.2	947	....	1.71	1.40	1.26	....	13.3	4.1	12.8	3.81	11.6	9.04	2.6		11.6	765	24.6	73	90	5	St-Cu	7	cqz
15.2 S	249.0	6	12.0	95	11.3	....	....	1.63	1.38	....	....	....	....	....	....	....	....	....		12.2	764	23.5	80	78	4	Ci-St	7	ocqr
12.4 S	248.8	7	10.9	141	11.4	568	478	1.57	1.33	1.92	1.93	13.6	4.5	12.4	3.43	11.7	1.23	4.8		11.3	765	25.2	63	100	3	St-Cu	2	bz
12.5 S	244.9	8	8.8	115	8.4	574	....	....	....	....	....	....	....	8.3	3.59	....	....	....		8.5	765	24.6	74	122	4	Cu	3	bc
		8	9.8	134	9.3	544	....	....	....	....	....	....	....	9.3	4.14	....	....	....		9.5	764	25.2	71	122	4	Cu	1	b
		8	10.8	104	10.3	538	....	....	....	....	....	....	....	10.3	4.03	....	....	....		10.5	764	25.5	70	122	4	Cu	1	b
		8	11.8	115	11.3	566	....	....	....	....	....	....	....	11.4	3.93	....	....	....		11.5	764	25.4	71	122	4	Cu	3	bc
		8	12.8	107	12.3	601	....	....	....	....	....	....	....	12.3	4.55	....	....	....		12.5	763	25.2	71	122	4	A-Cu	2	bc
		8	13.8	102	13.3	692	....	....	....	....	....	....	....	13.4	3.40	....	....	....		13.5	763	26.0	71	122	4	A-Cu	1	b
		8	14.8	107	14.3	530	....	....	....	....	....	....	....	14.4	3.24	....	....	....		14.5	762	25.5	73	122	4	A-Cu	1	b
		8	15.8	91	15.3	618	....	....	....	....	....	....	....	15.4	5.46	....	....	....		15.5	762	24.4	73	122	4	A-Cu	1	b
		8	16.8	93	16.3	542	....	....	....	....	....	....	....	16.3	3.50	....	....	....		16.5	762	24.2	77	122	4	Cu	4	bc
		8	17.8	79	17.3	467	....	....	....	....	....	....	....	17.2	3.43	....	....	....		17.5	762	23.2	76	122	4	Cu	4	bc
		8	18.8	103	18.3	501	....	....	....	....	....	....	....	18.2	3.87	....	....	....		18.5	763	22.9	75	122	4	Cu	5	bc

* Curie $\times10^{-18}$ per cubic centimeter. † Not used in the computation of Q, irregular. [1]Rain just before this set. [2]Rain 30 minutes before this set; heavy clouds approaching at end. [3] Vessel 2 to 4 miles from Easter Island.

12.5 S	244.9	Jan	8	19.8	98	19.3	480								19.3	3.48					19.5	763	23.0	80	111	4	St-Cu	3	bc
			8	20.8	115	20.4	558								20.3	3.66				1.2	20.5	763	22.8	78	111	4	Cu	1	b
			8	21.8	104	21.3	474								21.2	3.80					21.5	763	22.7	76	111	4	Cu	1	b
			8	22.8	103	22.3	510								22.3	4.13					22.5	763	22.7	78	111	4	Cu	1	b
			8	23.8	97	23.3	556								23.3	3.24					23.5	763	22.6	77	111	4	Cu	1	b
			9	0.8	108	0.3	543								0.3	4.09					0.5	763	22.5	74	111	4	Cu	2	b
			9	1.8	112	1.4	514								1.3	2.25					1.5	762	22.4	77	111	4	A-Cu	2	bc
			9	2.8	98	2.3	590								2.3	2.9					2.5	762	22.5	76	111	4	Fr-Cu	3	bc
			9	3.8	95	3.2	556								3.3	3.05					3.5	762	22.3	74	111	4	Fr-Cu	1	b
			9	4.8	94	4.2	543								4.2	2.98					4.5	762	22.3	75	111	4	St	2	bc
			9	5.8	135	5.2	514								5.3	2.75					5.5	763	22.4	71	111	4	St-Cu	2	b
			9	6.8	99	6.3	596								6.2	2.84					6.5	764	23.2	76	111	4	St-Cu	2	b
			9	7.8	107	7.3	635								7.3	2.61					7.5	764	24.2	69	111	4	St-Cu	3	bc
12.6 S	240.0		10	10.3	171	10.4	497	396	1.08	0.90	1.51	1.58	11.3	3.8	12.9	2.77	10.9	0.81	4.6		10.7	763	24.5	70	100	4	A-Cu	3	bcz
12.7 S	237.0		11	10.8	140	11.4	602	464	0.85	0.72	0.98	1.08			12.5	3.65	11.6	0.88	4.5		11.4	762	25.4	59	100	4	A-Cu	3	bc
14.4 S	234.6		12	11.2	[1]32																								or
			12	11.8	126	11.9	532	520	1.34	1.20	1.75	1.60	10.7	3.6							11.4	763	24.2	71	100	4	Nb	8	obc
16.0 S	232.9		13	11.2	188	11.4	526	419	1.25	1.14	1.65	1.89	15.0	5.0	12.4	4.16	11.9	1.01	2.9		11.7	763	25.8	74	78	3	A-Cu	3	bc
17.2 S	231.6		14	10.6	192	10.8	500	373	1.53	1.08	1.80	2.01	16.7	5.6	12.0	4.11	11.2	5.04	2.2		10.9	761	27.2	68	326	4	Ci	1	b
19.7 S	229.8		16	10.9	142	11.2	427	302	1.25	1.19	2.03	2.11	11.5	3.8	13.3	3.26	11.5	†0.38	7.8		11.3	759	25.6	71		0	A-Cu	8	o
20.1 S	229.1		17	11.7	190	11.7	499	392	1.34	0.98	1.87	1.74	14.7	4.9							11.9	761	25.3	78	11	2	Cu-Nb	10	orz
22.2 S	226.3		18	9.0	177	8.3	500														8.6	763	27.0	76	57	5	Fr-Cu	10	o
			18	9.9	147	9.4	466														9.6	763	27.0	74	57	5	Fr-Cu	9	o
			18	10.9	169	10.4	460														10.6	763	27.2	78	57	5	Cu	6	bc
			18	11.9	139	11.3	496														11.6	763	27.2	75	57	5	Ci-Cu	7	bc
			18	12.9	150	12.4	538														12.6	762	26.6	74	57	5	Ci-Cu	7	bcz
			18	13.9	143	13.4	460														13.6	762	27.2	75	57	5	Ci-Cu	7	bcz
			18	14.9	131	14.4	398														14.6	761	26.7	77	57	4	Ci-Cu	6	bcz
			18	15.9	120	15.4	545														15.6	761	26.6	76	57	4	Ci-Cu	6	bcz
			18	16.9	138	16.4	567														16.6	761	26.0	82	57	4	Cu	7	bcz
			18	17.9	127	17.4	433														17.6	762	25.8	78	57	4	Cu-Nb	7	bcz
			18	18.9	135	18.3	424														18.6	763	25.5	79	57	4	Cu-Nb, Ci-St	7	bcz
			18	19.9	155	19.4	538														19.6	763	25.4	81	57	4			bcz
			18	20.9	134	20.4	515														20.6	763	25.3	82	113	4	Cu	2	bcz
			18	21.9	124	21.4	468														21.6	763	25.5	78	113	4	Cu	3	bcz
			18	22.9	109	22.4	486														22.6	763	25.5	80	113	4	Cu	6	bcz
			18	23.9	117	23.4	438														23.6	763	24.8	86	124	4	Cu	2	bcz
			19	0.9	96	0.4	446														0.6	763	25.2	84	124	4	Cu	4	bcz
			19	1.9	135																1.6	763	24.5	84	124	4	Nb	7	crz
			19	2.9	132	2.5	463														2.6	762	25.0	82	124	4	Ci-St	7	cz
			19	3.9	136	3.6	495														3.6	763	25.0	81	124	4	A-Cu	2	bcz
			19	4.9	140	4.3	508														4.6	763	24.8	84	124	4	St-Cu	2	bcz
			19	5.9	173	5.5	574														5.6	764	25.0	80	102	5	Cu	2	bcz
			19	6.9	173	6.4	519														6.6	764	25.7	82	79	5	Ci-Cu	2	bcz
			19	7.9	181	7.3	592														7.6	764	26.7	81	79	5	Ci-Cu	2	bcz
26.5 S	223.7		20	10.5	263	10.9	662	446	1.72	1.15	1.80	1.79	25.2	4.3	11.9	2.66	11.2	0.00			11.0	769	26.3	77	170	5	A-Cu	7	cz
29.4 S	221.3		21	10.6	215	10.9	497	319	1.36	0.99	1.90	2.15	16.8	5.6	12.3	2.70					11.1	769	24.4	73	137	5	A-Cu	4	bcz
32.1 S	220.5		22	10.8	149	11.1	644	443	1.94	1.42	2.10	2.23	15.7	5.2	13.6	2.52					11.2	767	21.8	80	109	4	A-Cu	10	oz
34.7 S	220.1		23	11.8	124	12.0	574	362	1.67	1.38	2.02	2.65	13.6	4.5	13.1	3.33	12.4	0.00			12.0	768	19.5	88	116	4	A-St	10	og
37.9 S	215.6		27[2]	11.4	131	11.4	533	359	1.40	1.14	1.83	2.21	11.1	3.7							11.7	766	15.3	75	173	6	St-Cu	10	ogz
37.9 S	217.3		28	11.7	126	11.8	618	530	1.53	1.22	1.72	1.44	11.5	3.8	12.8	2.37	12.3	0.00			12.1	766	15.4	90	207	3	Nb	10	or
38.4 S	220.2		29	11.5	143	11.7	538	452	1.91	1.72	2.47	2.65	17.3	5.8	14.6	2.04	12.3	1.12	4.0		12.1	763	14.8	66	196	8	A-Cu	3	bc
38.5 S	222.0		30	9.1	277	8.5	432								8.6	3.04					8.8	768	13.8	62	196	1	Cu	5	bcz
			30	10.1	216	9.5	475								9.6	2.68					9.8	767	14.9	56		0	St-Cu	9	cz
			30	11.1	211	10.6	482								10.6	2.67					10.8	767	15.5	60		0	Cu	8	cz
			30	12.1	167	11.5	533								11.5	2.28					11.8	767	15.7	57		0	Cu	6	bcz

†Not used in the computation of Q, irregular. [1]Rain 15 minutes before observations; drizzling during set. [2]Strong gales on January 24, 25, and 26 prevented observations.

FINAL RESULTS OF OCEAN ATMOSPHERIC-ELECTRIC OBSERVATIONS ON THE CARNEGIE, 1915–1921—*Continued.*

CRUISE IV, PACIFIC OCEAN, 1916–1917—*Concluded.*

Lat.	Long. E. of Gr.	Date	Potential gradient L. M. T.	Potential gradient P	Ionic content L. M. T.	Ionic content n_+	Ionic content n_-	Conductivity λ_+	Conductivity λ_-	Ionic mobility k_+	Ionic mobility k_-	Current-density, i	Current-density, i	Penetrating radiation L. M. T.	Penetrating radiation R	Radioactive content L. M. T.	Ionization η_0	Ionization ΔT	Q	Meteorological data L. M. T.	Pressure	Temp. Cent.	Rel. hm.	Wind True dir.	Wind Force	Clouds Kind	Clouds Am't	Weather
°	°	1917	h	$\left(\frac{v}{m}\right)$	h	$\left(\frac{ions}{cc}\right)$		(ESU×10⁻⁴)		$\left(\frac{cm/s}{v/cm}\right)$		(ESU× 10⁻⁷)	$\left(\frac{a\times10^{-16}}{cm^2}\right)$	h	$\left(\frac{ions/cc}{s}\right)$	h	$\left(\frac{ions/cc}{s}\right)$	m	*	h	mm	°	p. ct.	°				
38.5 S	222.0	Jan 30	13.1	165	12.5	445	...	...	...	...	...	...	...	12.5	2.42	...	...	...		12.8	767	16.4	55	...	0	A-Cu	7	cs
		30	14.1	150	13.7	459	...	...	...	...	...	...	...	13.5	2.42	...	...	...		13.8	768	16.2	60	...	0	Cu	4	bcs
		30	15.1	136	14.5	506	...	...	...	...	...	...	...	14.6	2.32	...	...	...		14.8	767	16.0	62	...	0	Ci	9	os
		30	16.1	123	15.5	298	...	...	...	...	...	...	...	15.5	2.11	...	...	...		15.8	767	15.5	63	...	0	Cu	6	bcs
		30	17.1	146	16.5	564	...	...	...	...	...	...	...	16.5	2.40	...	...	...		16.8	767	14.5	63	...	0	Cu	7	cs
		30	18.1	119	17.6	484	...	...	...	...	...	...	...	17.6	2.27	...	...	...		17.8	767	14.4	69	...	0	Cu	10	os
		30	19.1	119	18.5	451	...	...	...	...	...	...	...	18.4	2.47	...	...	...		18.8	767	14.3	59	...	0	A-Cu	8	cs
		30	20.1	131	19.5	618	...	...	...	...	...	...	...	19.5	2.30	...	...	...		19.8	768	14.2	61	...	0	Cu	8-10	cos
		30	21.1	147	20.5	647	...	...	...	...	...	...	...	20.5	2.92	...	...	...		20.8	767	14.1	69	...	0	Cu	9	cs
		30	22.1	147	21.6	670	...	...	...	...	...	...	...	21.6	3.18	...	...	...		21.8	768	14.0	70	50	1	Cu	3	bcs
		30	23.1	176	22.5	648	...	...	...	...	...	...	...	22.6	2.86	...	...	...	1.4	22.8	768	14.0	67	50	1	Cu	3	bcs
		30	24.1	158	23.5	662	...	...	...	...	...	...	...	23.6	2.74	...	...	...		23.8	768	14.0	70	61	1	Cu	2	bcs
		31	1.1	151	0.5	621	...	...	...	...	...	...	...	0.5	3.15	...	...	...		0.8	769	14.1	69	72	1	Cu	5	bcs
		31	2.1	156	1.7	589	...	...	...	...	...	...	...	1.7	2.37	...	...	...		1.8	768	14.2	62	72	1	St-Cu	9	os
		31	3.1	213	2.6	574	...	...	...	...	...	...	...	2.6	2.49	...	...	...		2.8	768	14.1	64	72	2	St-Cu	10	os
		31	4.1	172	3.6	597	...	...	...	...	...	...	...	3.5	2.68	...	...	...		3.8	768	14.0	65	72	2	St-Cu	10	os
		31	5.1	200	4.6	611	...	...	...	...	...	...	...	4.5	2.42	...	...	...		4.8	768	13.9	66	72	3	A-Cu	7	cs
		31	6.1	205	5.6	640	...	...	...	...	...	...	...	5.5	2.82	...	...	...		5.8	768	13.8	65	72	3	A-Cu	3	bcs
		31	7.1	193	6.5	857	...	...	...	...	...	...	...	6.5	2.56	...	...	...		6.8	769	14.3	74	72	3	St-Cu	3	bcs
		31	8.1	186	7.5	649	...	...	...	...	...	...	...	7.5	1.91	...	...	...		7.8	768	15.4	68	72	3	Cu	4	bcs
41.9 S	222.1	Feb 1	11.1	226	11.5	648	418	1.27	0.80	1.36	1.33	15.6	5.2	12.3	2.45	11.9	0.50	6.0		11.8	765	15.7	77	107	4	A-Cu	2	b
43.7 S	221.5	2	11.6	118	11.8	937	783	1.94	1.45	1.44	1.28	13.3	4.4	12.4	2.66	...	...	...		11.8	763	12.3	80	176	2	A-St	9	cog
42.6 S	225.6	3	11.1	166	11.7	368	318	1.40	1.20	2.65	2.63	...	...	12.7	2.69	12.1	0.37	5.4		11.9	765	11.8	73	152	5	A-St	8	cs
43.0 S	228.4	4	11.3	190	11.4	409	325	1.29	0.90	2.19	1.92	13.9	4.6	12.8	2.89	12.0	1.04	4.8		11.9	762	12.5	78	221	5	A-St	10	os
45.1 S	232.3	5	11.0	114	11.1	520	386	1.56	1.36	2.08	2.45	11.1	3.7	12.9	2.65	11.8	2.08	3.3		11.7	761	12.0	88	222	6	A-St	10	og
46.4 S	236.5	6	11.1	162	11.1	644	522	1.59	1.20	1.72	1.60	15.1	5.0	...	...	11.7	0.88	4.9		11.5	761	9.2	65	178	5	Ci-Cu	8	cs
46.9 S	241.3	7	11.1	146	11.4	607	411	1.59	1.12	1.82	1.90	13.2	4.4	12.3	2.98	11.8	†0.30	9.5		11.5	764	8.7	72	202	7	A-Cu	10	o
48.8 S	244.0	8	11.5	164	10.3	404	373	1.28	0.99	2.20	1.84	...	...	12.7	3.26	12.2	1.78	3.5		12.1	762	9.2	92	249	6	A-St	10	og
51.9 S	247.6	9	11.5	156	11.6	...	...	1.66	1.27	...	...	15.2	5.1	...	...	...	...	...	...	11.8	755	8.7	94	251	7	A-St	10	om
54.0 S	252.0	10	12.0	66	12.4	...	...	1.16	0.55	...	...	3.8	1.3	...	...	...	...	...	...	12.2	750	7.2	95	274	5	A-St	10	om
54.6 S	257.8	11	11.8	134	12.1	...	...	1.45	0.93	...	...	10.6	3.5	12.8	3.64	...	...	...	...	12.4	747	5.0	80	231	6	St-Cu	10	sogm
55.2 S	264.3	12	12.0	156	11.5	673	467	1.27	1.11	1.31	1.65	12.4	4.1	12.6	3.53	...	...	...	...	11.2	749	6.1	78	253	7	Ci	4	bo
56.1 S	271.1	13	11.0	174	11.4	630	503	1.13	0.99	1.25	1.37	12.3	4.1	12.5	3.43	...	...	...	...	12.1	748	5.5	77	230	7	A-Cu	8	c
56.8 S	277.2	14	10.8	175	11.6	652	416	1.06	0.88	1.13	1.47	...	...	12.3	4.18	11.4	0.00	...	...	11.3	747	5.9	76	251	5	A-St	10	o
57.6 S	283.1	15	11.1	197	11.6	553	417	1.34	1.05	1.69	1.75	15.7	5.2	12.6	3.81	12.1	0.00	...	...	11.9	742	8.3	83	315	6	A-Cu	7	cs

*Curie×10⁻¹⁸ per cubic centimeter. †Not used in the computation of Q, irregular.

CRUISE IV, ATLANTIC OCEAN, 1917.

°	°	1917		h	(v/m)	h	(ions/cc)		(ESU×10⁻⁴)		(cm/s / v/cm)		(ESU× 10⁻⁷)	(a×10⁻¹⁶ / cm³)	h	(ions/cc / s)	h	(ions/cc / s)	m	*	h	mm	°	p.d.	°				
56.0 S	293.7	Feb	17	11.0	144	11.8	430	...	1.46	1.21	2.36	...	...	...	14.4	3.04	11.7	35.00	2.2	29.7	11.6	741	9.0	70	264	4	A-St	8	cogs
53.6 S	297.0		19	10.9	135	11.0	1216	794	1.32	0.93	0.75	0.82	10.1	3.4	12.3	3.96	11.5	12.70	3.2		11.3	750	9.0	74	149	2	A-St	4	bcs
51.6 S	297.1		20	9.0	268	8.4	917	...	...	...	...	...	...	...	8.4	4.57	...	...	...	...	8.7	743	9.3	96	306	3	Ci	1	bcs
			20	10.0	277	9.5	909	...	...	...	...	...	...	...	9.5	4.47	...	...	...	...	9.7	743	9.3	94	306	2	Ci	2	bcs
			20	11.0	288	10.5	942	...	...	...	...	...	...	...	10.5	4.86	...	...	...	...	10.7	743	10.0	90	329	2	Ci	7	cs
			20	12.0	281	11.5	794	...	...	...	...	...	...	...	11.6	4.83	...	...	...	...	11.7	743	10.6	88	340	2	Ci	8	cs
			20	13.1	260	12.4	901	...	...	...	...	...	...	...	12.5	4.22	...	...	...	...	12.7	742	11.3	83	329	3	Ci-St	8	bcs
			20	14.0	294	13.5	702	...	...	...	...	...	...	...	13.5	3.13	...	...	...	...	13.7	742	11.7	85	329	3	Ci	4	bcs
			20	15.0	248	14.5	677	...	...	...	...	...	...	...	14.5	3.25	...	...	...	...	14.7	742	11.2	87	340	4	Ci	6	cs
			20	16.0	217	15.5	1018	...	...	...	...	...	...	...	15.4	3.25	...	...	...	...	15.7	742	11.8	82	340	4	Ci	3	bcs
			20	17.0	190	16.5	796	...	...	...	...	...	...	...	16.5	3.58	...	...	...	...	16.7	742	11.2	84	340	4	Ci	4	bcs
			20	18.0	149	17.5	922	...	...	...	...	...	...	...	17.5	3.04	...	...	...	...	17.7	742	11.0	88	340	4	Ci	2	bcs
			20	19.0	156	18.5	660	...	...	...	...	...	...	...	18.5	3.19	...	...	...	...	18.7	743	10.5	85	318	4	Ci	1	bs
			20	20.0	156	19.4	506	...	...	...	...	...	...	...	19.4	3.49	...	...	...	...	19.7	743	10.3	84	306	5	Ci	1	bs
			20	21.0	166	20.5	494	...	...	...	...	...	...	...	20.5	3.35	...	...	...	...	20.7	744	10.4	86	306	5	Ci	1	bs
			20	22.0	191	21.5	521	...	...	...	...	...	...	...	21.5	4.19	...	...	...	...	21.7	745	10.4	83	306	5	Ci	1	bs
			20	23.0	206	22.5	491	...	...	...	...	...	...	...	22.5	3.53	...	...	...	...	22.7	746	10.2	88	306	5	Ci	1	bs
			20	24.0	210	23.4	460	...	...	...	...	...	...	...	23.4	3.75	...	...	...	...	23.7	745	10.2	86	306	5	Ci	1	bs
			21	1.0	216	0.4	420	...	...	...	...	...	...	...	0.4	2.77	...	...	...	...	0.7	746	10.8	81	318	4	Ci	2	bs
			21	2.0	213	1.6	449	...	...	...	...	...	...	...	1.5	2.52	...	...	...	...	1.7	746	11.0	77	318	5	Ci	1	bs
			21	3.0	193	2.5	420	...	...	...	...	...	...	...	2.5	*3.42	...	...	...	...	2.7	746	10.9	77	306	5	Ci	0	bs
			21	4.0	167	3.6	531	...	...	...	...	...	...	...	3.4	3.35	...	...	...	...	3.7	747	10.7	80	293	6	Ci	0	bs
			21	5.0	182	...	...	...	...	...	...	...	...	...	4.5	3.81	...	...	...	...	4.7	747	10.6	79	293	6	A-St	2	bcs
			21	7.0	169	6.7	545	...	...	...	...	...	...	...	6.7	3.09	...	...	...	...	6.7	748	10.8	86	293	6	A-St	2	bcs
			21	8.0	208	7.5	635	...	...	...	...	...	...	...	7.5	3.21	...	...	...	...	7.7	749	10.8	81	293	6	A-St	2	bcs
47.9 S	300.1		22	12.4	207	12.6	601	365	0.77	0.46	0.89	0.88	8.5	2.8	...	...	...	...	...	...	12.7	761	13.0	82	122	1	A-Cu	3	bo
40.1 S	303.0		26	11.7	217	12.1	787	491	1.80	1.32	1.65	1.87	22.6	7.5	14.5	3.15	12.3	251.86	2.5	669.8	12.1	756	15.3	82	231	6	Cu	6	bcs
38.2 S	304.1		27	10.7	154	10.8	667	530	1.47	1.30	1.49	1.68	14.2	4.7	12.3	3.10	11.4	3.08	3.8	240.9	11.2	761	17.4	71	162	2	A-Cu, Ci-St	6	bcs
Buenos Aires																													

CRUISE V, ATLANTIC OCEAN, 1917.

°	°	1917		h	(v/m)	h	(ions/cc)		(ESU×10⁻⁴)		(cm./s. / v/cm)		(ESU× 10⁻⁷)	(a×10⁻¹⁶ / cm³)	h	(ions/cc / s)	h	(ions/cc / s)	m	*	h	mm	°	p.d.	°				
Buenos Aires																													
35.4 S	303.4	Dec	6	11.1	180	12.5	439	490	...	...	...	...	...	...	...	...	...	...	...	...	11.5	760	20.8	75	49	4	Ci-Cu	7	cs
35.8 S	304.1		7	9.4	154	9.6	612	717	0.93	0.92	1.66	0.89	9.5	3.2	...	...	...	...	...	...	9.7	760	22.3	68	26	2	...	0	b
37.7 S	305.0		8	9.4	176	9.5	...	...	1.12	1.00	...	...	16.0	5.3	...	...	...	...	...	...	10.7	757	18.8	86	26	3	Ci, Nb	9	cr
39.2 S	304.9		9	9.5	201	9.9	239	212	1.30	1.12	3.12	3.67	23.5	7.8	...	...	...	...	...	...	10.5	753	14.4	79	240	5	Ci-Cu	5	cs
38.9 S	303.2		10	9.8	185	9.7	658	532	2.27	2.06	2.40	2.89	26.7	8.9	...	...	10.5	0.28	5.7		10.5	765	16.2	58	162	3	Cu	8	c
40.0 S	302.4		11	9.7	280	10.2	239	234	1.70	1.65	5.15	3.12	26.5	8.8	...	...	...	...	...		11.6	763	17.8	79	343	2	Ci-St	2	bc
41.8 S	300.7		12	9.3	258	9.6	349	485	...	...	...	...	...	...	...	...	10.0	79.90	1.5		10.2	757	16.8	85	8	5	Ci-St	2	bc
43.4 S	299.2		13	10.2	153	10.0	436	628	1.15	0.97	1.84	1.08	10.8	3.6	...	...	...	...	...		11.0	752	15.8	71	223	4	Nb	9	cr
43.1 S	298.8		14	9.9	161	10.1	534	667	1.58	1.31	2.03	1.38	15.4	5.1	...	...	10.6	65.30	2.3	30.0	10.8	765	17.0	61	280	4	St	1	b
44.3 S	297.7		15	9.7	232	10.2	522	542	1.19	1.01	1.58	1.29	17.0	5.7	...	...	10.8	†15.57	18.1		10.7	768	18.5	64	348	6	...	0	b
47.3 S	297.0		16	10.2	186	10.5	531	624	1.13	0.86	1.48	0.96	11.0	3.7	...	...	10.8	20.97	2.3		11.2	751	15.5	62	248	5	Ci-St	5	bc
49.6 S	297.3		17	10.1	139	9.8	...	...	...	2.28	...	...	...	...	...	...	...	...	...		11.2	745	11.9	61	248	6	Cu-Nb	6	bcq
51.3 S	297.8		18	10.3	[1]242	10.4	508	500	1.65	1.23	2.25	1.71	23.2	7.7	...	...	11.6	0.79	6.3		11.8	742	9.1	70	260	6	Cu-Nb	5-9	crq
53.0 S	299.8		19	10.0	148	10.1	449	493	1.40	1.42	2.16	2.00	13.7	4.6	...	...	10.9	†0.41	12.5	...	10.2	748	7.2	61	214	7	Nb	9	oq
53.2 S	300.7		20	9.7	155	9.9	...	...	1.22	0.90	...	...	11.0	3.7	...	...	...	...	...	...	10.3	749	7.7	69	192	3	Ci-Cu	3	bc
53.5 S	299.6		21	10.5	190	10.3	450	498	1.11	1.21	1.71	2.06	13.1	4.4	...	...	...	...	...	...	10.8	749	9.2	65	...	0	Cu-Nb	9	c
55.0 S	297.1		22	11.7	126	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	12.0	741	7.7	87	104	4	Nb	10	odr
56.1 S	295.6		23	9.9	97	10.3	...	...	0.84	0.84	...	...	5.5	1.8	...	...	...	...	...	...	11.5	742	6.3	93	263	2	Nb	10	od

* Curie×10⁻¹⁶ per cubic centimeter. † Not used in the computation of Q_1 irregular. [1] Rain and hail before and after this set.

FINAL RESULTS OF OCEAN ATMOSPHERIC-ELECTRIC OBSERVATIONS ON THE CARNEGIE, 1915–1921—*Continued.*

CRUISE V, PACIFIC OCEAN, 1917–1918.

Lat.	Long. E. of Gr.	Date	Potential gradient: L. M. T.	Potential gradient: P	Ionic content: L. M. T.	Ionic content: n_+	Ionic content: n_-	Conductivity: λ_+	Conductivity: λ_-	Ionic mobility: k_+	Ionic mobility: k_-	Current-density, i	Current-density, i	Penetrating radiation: L. M. T.	Penetrating radiation: R	Radioactive content: Ionization: L. M. T.	Radioactive content: Ionization: η_0	Radioactive content: Ionization: ΔT	Radioactive content: Q	Meteorological data: L. M. T.	Pressure	Temp. Cent.	Rel. hm.	Wind: True dir.	Wind: Force	Clouds: Kind	Clouds: Am't	Weather
°	°	1917	h	(v/m)	h	(ions/cc)		(ESU×10⁻⁴)		(cm/s / v/cm)		(ESU× 10⁻⁷)	(a×10⁻¹⁶ / cm²)	h	(ions/cc / s)	h	(ions/cc / s)	m	*	h	mm	°	p.ct.	°				
58.7 S	288.7	Dec 25	9.7	175	10.1			0.94	0.71			9.6	3.1			10.4	0.00			11.0	737	7.6	77	324	7	Cu–Nb	2	boqr
58.3 S	285.7	26	10.2	160	10.6			1.25	0.87			11.3	3.8							12.5	723	7.8	87	67	3	Nb	10	moqr
57.5 S	286.6	27	10.0	197	10.4			1.04	0.88			12.6	4.2			10.7	†0.29	18.9		11.5	737	6.7	75	337	7	Cu–Nb	4–6	bc
58.4 S	285.0	28	9.9	175	10.2	761	171	1.40	1.07	1.27	4.35	14.4	4.8			10.8	†0.27	15.3		11.7	733	7.9	73	315	5	Ci, Cu–Nb	5	bcr
59.1 S	284.4	29	9.8	146	10.0	[1]701	164	1.11	0.97	1.11	4.11	10.1	3.4							11.2	736	6.0	89		0	A–St, St–Nb	10	o
58.6 S	281.4	30	9.6	208	10.0	410	153	1.08	0.69	1.83	3.14	12.3	4.1							11.0	748	6.9	78	203	4	Cu–Nb	9	cqr
56.2 S	279.9	31	9.7	144	10.0			1.08	0.90			9.6	3.2			10.9	0.87	8.0		10.8	756	7.3	92	260	6	A–St, Nb	10	od
		1918																	1.7									
52.9 S	279.8	Jan 1	9.8	98	10.1	426	332	1.29	1.05	2.10	2.20	7.6	2.5			11.0	0.71	8.6		10.8	759	8.0	94	293	6		10	o
52.1 S	279.1	3	10.5	200	10.8	544	359	1.37	1.15	1.75	2.24	16.8	5.6							10.7	756	9.7	76	270	8	Ci, St, Nb	6	o
50.5 S	279.9	4	9.9	138	10.4	710	397	1.39	1.12	1.36	1.96	11.5	3.8							10.7	749	8.4	73	259	5	Ci–Cu, Nb	7	crq
47.9 S	279.4	5	10.6	102	10.8	762	524	1.19	0.93	1.08	1.23	7.2	2.4			11.2	0.00			11.2	753	9.0	71	224	6	Cu–Nb	7	cqrh
44.9 S	280.2	6	10.3	165	10.6	774	641	1.53	1.31	1.38	1.42	15.6	5.1			10.8	0.00			10.5	763	12.5	76	279	5	Cu–Nb	8	c
43.0 S	281.3	7	10.2	128	10.4	777	628	1.20	1.29	1.07	1.43	10.6	3.5			10.8	0.00			10.5	772	13.8	70	245	2	Ci–Cu	7	c
41.6 S	282.2	8	11.0	155	11.0	520	410	0.97	0.66	1.29	1.12	8.4	2.8			11.7	†0.14	20.1		11.5	771	14.2	73	244	3	A–St	10	o
38.5 S	284.3	9	8.9	150	8.5	363		1.36		2.60										8.5	765	15.2	83	175	4	Ci	10	o
		9	9.8	105	9.3	361		1.54		2.96										9.5	763	15.6	85	153	4	Ci	10	o
		9	10.8	185	10.2	516		1.58		2.13										10.5	763	15.8	85	153	4	Ci	10	o
		9	11.8	136	11.4	536		1.48		1.92										11.5	763	16.0	85	153	4	Ci, Nb	10	o
		9	12.8	204	12.3	573		1.45		1.76										12.5	762	16.0	87	153	4	Ci	10	o
		9	13.8	263	13.1	468		1.41		2.09										13.5	762	16.3	83	153	4	Ci	10	o
		9	14.8	225	14.4	621		1.45		1.62										14.5	761	16.3	84	153	4	Ci	10	o
		9	15.9	163	15.6	520		1.53		2.04										15.5	761	16.0	84	153	4	Ci	10	o
		9	16.9	171	16.4	539		1.50		1.93										16.5	760	15.7	86	153	5	Cu, St–Nb	8	o
		9	17.9	166	17.3	502		1.49		2.06										17.5	760	15.3	87	153	5	Ci	10	o
		9	18.8	142	18.3	504		1.46		2.01										18.5	760	14.8	86	153	5	A–St, St–Nb	10	o
		9	19.8	134	19.3	474		1.25		1.83										19.5	759	15.2	85	153	5	Ci, Nb	10	o
		9	20.8	138	20.2	502		1.48		2.05										20.5	759	15.2	83	153	6	Ci	10	o
		9	21.8	169	21.2	564		1.53		1.88										21.5	759	15.2	85	153	6	Ci	10	o
		9	22.8	153	22.4	541		1.54		1.98										22.5	759	15.0	85	153	6	St, Nb	4	bc
		9	23.8	200	23.4	537		1.41		1.82										23.5	758	14.8	89	153	6	St, Nb	3	bc
		10	0.8	180	0.3	475		1.39		2.03										0.5	757	15.2	86	153		St	3	bc
		10	1.9	167	1.4	409		1.06		1.80										1.5	756	15.0	87	153	6		2	b
		10	2.8	151	2.3	414		0.07		0.12										2.5	756	15.0	84	153	6		2	b
		10	3.7	163	3.2	388		0.44		0.79										3.5	756	15.0	86	153	6		0	b
		10	4.8	153	4.3	410		0.29		0.49										4.5	756	15.2	85	153	6		0	b
		10	5.9	185	5.4	234		0.59		1.75										5.5	757	15.8	85	153	6	Nb	0–1	bc
		10	6.8	313	6.3	553		0.58		0.73										6.5	757	16.5	86	153	6	Cu	2	bc
		10	7.7	300	7.3	253		1.23		3.38										7.5	758	15.7	86	153	5	Ci	6–10	co
Talcahuano																												
35.4 S	286.1	24	10.5	194	9.8	598	447	0.71	0.60	0.82	0.93					10.0	†0.85	10.3		9.8	766	18.1	81	128	3	Ci–Cu	7	c
33.2 S	284.9	25	10.5	221	10.6	411	314	0.97	0.72	1.64	1.59	12.4	4.1			11.0	†0.33	17.5		10.8	763	20.3	72	195	5	Cu	0–1	b

*Curie×10⁻¹⁶ per cubic centimeter. †Not used in the computation of Q, irregular. [1] Small engine running.

31.4 S	284.1	Jan	26	11.2	186	11.0	302	216	0.69	0.50	1.59	1.61	7.4	2.5			11.9	†0.27	15.1		11.5	762	22.5	61		0	Cu	1	b
30.7 S	283.7		27	11.1	229	10.8	337	194	1.04	0.72	2.15	2.58	13.4	4.5			11.8	0.00			11.4	761	23.4	77	307	3	Ci-Cu	5	bc
29.2 S	281.7		28	11.4	157	10.8			0.76	0.56							11.8	†0.20	17.2		11.5	764	22.7	63	195	4	Cu	1	b
27.5 S	279.0		29	10.8	127	10.5	428	344	1.11	1.04	1.80	2.10	9.1	3.0			11.2	†0.05	32.6		11.0	766	20.2	75	150	5	St, Nb	......	c
28.0 S	275.7		30	10.5	154	10.2	533	392	1.44	1.20	1.87	2.13	13.6	4.5			11.5	†0.20	23.3		11.2	768	21.5	63	117	5	Cu-Nb	7	cq
30.3 S	272.4		31	8.8	169	8.2	673		1.70		1.75										8.5	765	20.2	78	152	5	Ci-Cu	8	bc
			31	9.8	130	9.3	537		1.72		2.23										9.5	765	20.3	78	152	5	Ci-Cu	9	cs
			31	10.8	119	10.2	641		1.71		1.85										10.5	766	20.3	78	152	5	Ci, Nb	......	cqr
			31	11.8	140	11.4	589		1.79		2.11										11.5	766	22.3	71	140	5	Cu	4	bc
			31	12.8	131	12.1	701		1.66		1.84										12.5	766	22.7	70	140	5	Cu	5	bc
			31	13.7	162	13.3	654		1.65		1.75										13.5	765	21.2	76	140	5	Cu-Nb	6	bc
			31	14.8	177	14.3	605		1.63		1.87										14.5	764	21.0	73	140	5	Cu	6	bc
			31	15.8	155	15.1	609		1.60		1.82										15.5	765	21.4	69	120	5	Cu-Nb	9	c
			31	16.8	145	16.4	521		1.38		1.84										16.5	765	21.0	73	140	5	Ci-Cu, Nb	10	o
			31	17.8	156	17.3	483		1.36		1.95										17.5	765	20.8	77	140	5	Cu-Nb	10	orq
			31	18.8	153	18.1	449		1.27		1.96										18.5	765	20.4	76	140	5	Cu, Nb	8	oq
			31	19.8	172	19.2	432		1.12		1.80										19.5	766	20.6	74	140	5	Cu-Nb	9	cqr
			31	20.8	143	20.4	461		1.27		1.91										20.5	766	20.8	73	140	5	Cu-Nb	7	bc
			31	21.8	172	21.4	416		1.13		1.80										21.5	766	20.9	72	120	5	Cu-Nb	8	cqr
			31	22.8	104	22.4	498		1.19		1.94										22.5	765	20.5	72	120	5	Cu-Nb	10	oqr
			31	23.8	136	23.5	462		1.15		1.73										23.5	766	20.6	72	120	5	Cu-Nb	10	o
		Feb	1	0.8	151	0.4	507		1.36		1.86										0.5	765	20.3	69	120	5	Cu-Nb	10	o
			1	1.8	131	1.5	407		1.28		2.18										1.5	765	20.2	74	120	5	Cu-Nb	10	o
			1	2.7	129	2.1	432		1.30		2.09										2.5	765	20.3	62	120	5	Cu-Nb	10	o
			1	3.8	130	3.2	523		1.30		1.85										3.5	765	20.0	68	120	5	Cu-Nb	10	o
			1	4.7	129	4.3	534		1.40		1.94										4.5	766	20.2	63	120	5	Cu-Nb	10	o
			1	5.7	135	5.1	580		1.58		1.89										5.5	766	20.0	65	120	5	Cu-Nb	10	or
			1	6.8	146	6.8	586		1.53		1.81										6.5	766	20.0	72	120	6	Cu-Nb	10	o
			1	7.8	174	7.2	598		1.55		1.80										7.5	766	19.7	77	120	6	Cu, Nb	10	o
22.9 S	269.4		2	10.8	130	10.7	594	470	1.65	1.42	1.93	2.10	13.3	4.4			11.4	†0.19	21.4		11.2	770	21.8	62	130	5	Cu-Nb	9-10	o
25.3 S	268.1		3	10.7	119	10.3	783	641	1.92	1.47	1.70	1.59	13.4	4.5			11.1	†0.27	14.2		10.8	772	20.3	70	87	4	Cu, Cu-Nb	......	o
26.2 S	268.6		4	10.4	115	10.4	941	717	1.60	1.64	1.18	1.50	13.1	4.0			10.9	†0.22	15.8		10.5	770	20.3	60	9	2	Cu, Cu-Nb	8	c
26.9 S	269.9		5	11.0	138	10.9	680	547	1.38	1.07	1.30	1.36	11.3	3.8			11.5	0.00			11.0	769	21.4	64	312	3	St-Cu	8	c
27.0 S	271.9		6	11.0	124	10.9	637	556	1.31	1.03	1.32	1.29	10.0	3.3			11.5	†0.20	11.5		11.0	767	21.0	65	323	4	St-Cu	1	b
26.9 S	275.7		7	8.8	164	8.3	332		1.22		2.55										8.5	762	19.7	87	334	4	Ci, Ci-St	9	c
			7	9.8	167	9.3	335		1.12		2.39										9.5	761	20.2	79	334	5	St-Cu	7	bc
			7	10.8	172	10.2	497		1.13		1.58										10.5	761	21.3	74	334	5	Cu	7	bc
			7	11.8	177	11.3	468		1.21		1.80										11.5	761	20.8	79	334	5	St	1	b
			7	12.8	159	12.2	489		1.30		1.70										12.5	761	20.9	76	334	5	St	1	b
			7	13.8	160	13.2	468		1.19		1.77										13.5	760	20.8	79	334	5	St	1	b
			7	14.8	155	14.4	466		1.13		1.68										14.5	759	21.1	79	334	5	Ci	1	bs
			7	15.7	157	15.4	446		1.11		1.73										15.5	759	20.5	80	334	5	Ci	7	bc
			7	16.8	124	16.2	441		1.06		1.67										16.5	759	20.2	83	334	5	Ci-Cu	9	c
			7	17.8	125	17.2	398		1.03		1.80										17.5	759	19.0	88	334	5	Cu	10	o
			7	18.8	115	18.3	404		1.01		1.74										18.5	759	18.6	87	334	5	Cu-Nb	9	c
			7	19.8	120	19.2	414		0.95		1.59										19.5	759	18.3	91	334	5	Cu	4	bc
			7	¹20.8	107	20.2	306		0.94		2.13										20.5	759	18.3	91	334	5	Cu	5	bc
36.2 S	278.3		8	10.9	154	10.8	358	315	1.22	0.96	2.36	2.12	11.2	3.7			11.5	†0.38	12.7		10.9	764	20.5	85	333	5	Cu-Nb, A-St	10	o
34.4 S	278.7		9	10.4	149	10.4	478	301	1.18	0.87	1.72	1.55	9.6	3.2			11.1	†0.30	10.7		10.8	766	21.3	69	152	5	Cu	5	bc
33.1 S	278.6		10	10.5	160	10.6	534	476	1.22	1.08	1.59	1.58	12.3	4.1			11.2	0.73	5.0		10.7	765	21.8	60	120	4	Cu	1	b
31.1 S	278.5		10	21.8	117	21.4	530		1.04		1.36										21.5	767	18.8	74	151	2		0	b
			10	22.8	117	22.2	529		1.03		1.35										22.5	765	18.5	74	151	2		0	b
			10	23.7	122	23.3	488		0.99		1.41										23.5	763	18.5	76	151	2		1	b
			11	0.8	150	0.3	535		1.02		1.35										0.5	762	18.2	78	151	3		2	b
			11	1.8	124	1.3	382		0.96		1.84										1.5	762	18.3	73	151	3		2	b
			11	2.7	113	2.3	387		0.96		1.72										2.5	762	18.2	71	151	3		2	b

†Not used in the computation of Q, irregular. ¹Observations discontinued on account of excessive humidity.

FINAL RESULTS OF OCEAN ATMOSPHERIC-ELECTRIC OBSERVATIONS ON THE CARNEGIE, 1915–1921—*Continued.*

CRUISE V, PACIFIC OCEAN, 1917–1918 *Continued.*

Lat.	Long. E. of Gr.	Date	Potential gradient L.M.T.	Potential gradient P	Ionic content L.M.T.	Ionic content n_+	Ionic content n_-	Conductivity λ_+	Conductivity λ_-	Ionic mobility k_+	Ionic mobility k_-	Current-density, i	Current-density, i	Penetrating radiation L.M.T.	Penetrating radiation R	Radioactive content Ionization L.M.T.	Radioactive content Ionization q_0	Radioactive content Ionization ΔT	Radioactive content Q	Meteorological data L.M.T.	Pressure	Temp. Cent.	Rel. hm.	Wind True dir.	Wind Force	Clouds Kind	Clouds Am't	Weather
°	°	1918	h	$\left(\frac{v}{m}\right)$	h	$\left(\frac{ions}{cc}\right)$		(ESU×10⁻⁴)		$\left(\frac{cm/s}{v/cm}\right)$		(ESU×10⁻⁷)	$\left(\frac{a\times10^{-16}}{cm^2}\right)$	h	$\left(\frac{ions/cc}{s}\right)$	h	$\left(\frac{ions/cc}{s}\right)$	m	*	h	mm	°	p. ct.	°				
31.1 S	278.5	Feb 11	3.7	142	3.2	403	...	0.92	...	1.59	...	...	...	...	...	...	...	...		3.5	762	18.2	73	151	3	Nb	3	bc
		11	4.7	112	4.1	413	...	1.05	...	1.76	...	...	...	...	...	...	...	...	0.0	4.5	762	18.4	72	151	3	Cu–Nb	6	bc
		11	5.7	147	5.1	438	...	0.94	...	1.49	...	...	...	...	...	...	...	...		5.5	762	18.7	72	151	3	Cu, Cu–Nb	9	c
		11	6.8	127	6.2	452	...	1.10	...	1.69	...	...	...	...	...	...	...	...		6.5	763	19.0	74	151	3	Cu, Nb	9	c
		11	7.7	136	7.2	402	...	1.08	...	1.87	...	...	...	...	...	...	...	...		7.5	763	20.2	71	151	4	Cu, Nb	9	c
30.4 S	278.4	11	10.8	135	11.1	466	397	1.11	1.05	1.65	1.84	9.7	3.2	...	...	11.6	†0.25	11.4		11.2	767	20.7	60	151	4	Cu	3	bc
28.2 S	278.1	12	11.0	132	11.1	539	441	1.23	1.03	1.59	1.62	9.9	3.3	...	...	11.7	0.51	6.3		11.2	765	20.9	63	151	4	A–St, Cu–Nb	10	o
25.8 S	278.1	13	10.8	169	10.8	480	361	1.10	0.99	1.59	1.90	12.8	4.3	...	...	11.5	†0.48	6.3		10.9	764	23.0	67	127	4	Cu	3	bc
24.0 S	278.5	14	10.7	150	10.8	523	357	1.04	0.71	1.38	1.38	8.8	2.9	...	...	11.6	†0.22	8.4		10.8	762	22.8	67	127	2	A–St	10	o
22.6 S	278.9	15	10.9	182	11.0	459	359	0.86	0.58	1.30	1.12	8.7	2.9	...	...	11.7	0.55	4.7		11.0	761	24.5	57	80	2	Cu	8	c
21.0 S	279.7	16	10.6	192	10.9	268	212	0.68	0.46	1.76	1.51	7.3	2.4	...	...	11.8	0.47	5.4		10.7	761	25.0	59	113	1	Cu	4	bc
19.2 S	281.0	17	8.8	243	8.4	281	...	0.69	...	1.70	...	...	...	...	...	...	...	...	...	8.5	760	22.6	83	124	2	Ci	10	o
		17	9.8	222	9.4	290	...	0.58	...	1.39	...	...	...	...	...	...	...	...	...	9.5	760	23.2	82	124	2	Ci	10	o
		17	10.8	324	10.2	290	...	0.59	...	1.40	...	...	...	...	...	...	...	...	...	10.5	759	25.3	71	124	2	Ci, Cu	9	oz
		17	11.8	320	11.4	202	...	0.55	...	1.89	...	...	...	...	...	...	...	...	...	11.5	759	24.8	76	124	2	Ci, Cu	9	cz
		17	12.8	319	12.3	225	...	0.45	...	1.39	...	...	...	...	...	...	...	...	...	12.5	760	24.4	77	124	2	Ci	10	oz
		17	13.8	335	13.4	216	...	0.46	...	1.48	...	...	...	...	...	...	...	...	...	13.5	759	24.2	74	124	3	Ci	10	oz
		17	14.8	309	14.4	193	...	0.42	...	1.51	...	...	...	...	...	...	...	...	...	14.5	758	24.2	72	124	3	Ci, Cu	9	cz
		17	15.8	300	15.4	209	...	0.54	...	1.79	...	...	...	...	...	...	...	...	...	15.5	758	24.4	71	124	3	Ci, Cu	9	cz
		17	16.8	272	16.3	171	...	0.45	...	1.83	...	...	...	...	...	...	...	...	...	16.5	758	23.2	72	124	3	Cu	10	o
		17	17.9	197	17.2	223	...	0.47	...	1.47	...	...	...	...	...	...	...	...	...	17.5	759	22.5	78	124	3	Cu	9	c
		17	18.8	182	18.2	198	...	0.44	...	1.58	...	...	...	...	...	...	...	...	...	18.5	758	22.3	79	124	3	St–Cu	9	c
		17	19.8	177	19.3	152	...	0.40	...	1.83	...	...	...	...	...	...	...	...	...	19.5	759	22.3	76	124	3	St–Cu	7	bc
		17	20.8	182	20.4	164	...	0.50	...	2.25	...	...	...	...	...	...	...	...	...	20.5	760	22.3	74	124	3	St–Cu	6	bc
		17	21.8	161	21.4	159	...	0.35	...	1.53	...	...	...	...	...	...	...	...	...	21.5	760	22.4	75	124	3	Cu	10	o
		17	22.8	161	22.3	164	...	0.59	...	2.50	...	...	...	...	...	...	...	...	...	22.5	760	22.4	77	113	3	Cu	10	o
		17	23.8	181	23.3	152	...	0.56	...	2.56	...	...	...	...	...	...	...	...	...	23.5	760	22.4	80	113	3	Cu	10	o
		18	0.8	171	0.3	154	...	0.60	...	2.70	...	...	...	...	...	...	...	...	...	0.5	760	22.3	77	113	3	Cu	10	o
		18	1.8	192	1.3	158	...	0.47	...	2.14	...	...	...	...	...	...	...	...	...	1.5	759	22.0	78	113	...	Cu	6	bc
		18	2.8	228	2.2	167	...	0.62	...	2.30	...	...	...	...	...	...	...	...	...	2.5	759	21.9	79	113	...	Cu	5	bc
		18	3.9	185	3.2	181	...	0.59	...	2.26	...	...	...	...	...	...	...	...	...	3.5	759	21.7	84	113	...	Cu	4	bc
		18	4.8	207	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	4.5	759	21.7	82	124	...	Cu	3	bc
		18	5.8	212	5.4	73	...	0.55	...	5.24	...	...	...	...	...	...	...	...	...	5.5	760	21.8	79	124	...	Cu	4	bc
		18	6.9	218	6.4	148	...	0.62	...	2.91	...	...	...	...	...	...	...	...	...	6.5	760	22.8	76	124	...	Cu–Nb	6	bc
		18	7.7	289	7.3	95	...	0.80	...	5.84	...	...	...	...	...	...	...	...	...	7.5	761	22.6	82	124	...	Cu	3	bc
16.6 S	281.8	19	11.2	236	11.1	201	232	0.95	0.54	2.27	1.63	11.7	3.9	...	...	11.9	0.00	...	...	11.3	762	27.5	68	123	2	Cu	4	bc
14.4 S	282.1	20	10.9	198	11.0	208	201	0.97	0.64	3.23	2.22	10.6	3.5	...	...	...	...	...	...	10.9	761	26.0	76	122	3	Cu	1	b
13.4 S	282.5	21	10.9	211	10.9	294	250	0.98	0.81	2.32	2.25	12.6	4.2	...	...	11.6	2.12	5.6	6.7	11.0	760	24.6	71	167	3	Ci	3	b
12.4 S	282.5	22	10.4	236	11.2	...	...	0.31	0.20	...	...	...	...	...	...	...	...	...	...	10.5	759	22.2	88	212	1	Ci	3	b
Callao																												
11.0 S	281.6	Mar 30	10.8	630	10.6	...	...	0.24	0.17	...	...	8.6	2.9	...	...	11.4	†0.20	10.0		11.2	761	20.1	99	144	1	...	...	fw
10.1 S	279.6	31	10.5	200	10.5	422	299	1.29	1.10	2.12	2.55	15.9	5.3	...	...	11.1	2.51	3.0		11.0	760	24.0	81	144	4	Ci, Cu	4	bc

*Curie×10⁻¹⁶ per cubic centimeter. †Not used in the computation of Q, irregular.

10.2 S	277.4	Apr	1	10.4	113	10.2	394	317	1.81	1.49	3.19	3.11	12.1	4.0	......	......	10.9	0.64	2.5		10.8	759	27.1	71	156	4	Cu	4	bc
11.3 S	275.1		2	10.2	108	10.2	490	364	1.89	1.71	2.68	3.26	13.0	4.3	......	......	10.8	0.55	3.2		10.8	760	27.3	66	156	4	Ci-Cu, Cu	2	b
12.2 S	273.5		3	10.9	149	10.9	442	324	1.38	1.06	2.17	2.27	12.1	4.0	......	......	11.5	0.57	3.6	0.0	11.3	760	25.5	77	146	3	A-St, Cu-Nb	9	c
14.0 S	271.3		4	10.7	188	10.7	438	342	2.00	1.66	3.17	3.37	22.9	7.6	......	......	11.6	0.70	3.1		11.3	760	25.7	70	147	6	A-St, Cu	8	c
15.9 S	269.0		5	10.4	134	10.4	543	373	1.90	1.55	2.43	2.89	15.4	5.1	......	......	10.9	0.00	......		10.9	763	24.5	68	124	5	Cu, St-Cu	8	c
16.2 S	266.5		6	10.6	219	10.6	656	692	1.03	0.90	1.09	0.90	14.1	4.7	......	......	11.1	0.28	4.2		11.1	762	24.1	80	113	4	......	0	b
15.6 S	263.6		7	11.1	171	10.9	624	381	1.65	1.28	1.84	2.33	16.7	5.6	......	......	......	......	......	......	11.3	762	24.6	68	113	3	Cu, St-Cu	6	bcq
13.8 S	264.2		8	10.8	120	10.6	541	459	2.25	1.54	2.89	2.30	15.2	5.1	......	......	11.4	0.00	......	......	11.2	762	26.1	68	113	5	Cu	1	b
12.2 S	265.0		9	10.8	150	10.8	490	351	1.89	1.47	2.63	2.91	16.8	5.6	......	......	11.3	0.00	......	......	11.1	760	27.5	66	113	3	Fr-Cu	1	b
10.0 S	266.4		10	8.8	133	8.3	459	.....	1.62	......	2.45										8.5	759	27.0	70	123	4	Cu	1	b
			10	9.8	160	9.4	474	.....	1.57	......	2.30										9.5	758	28.2	65	123	4	Cu	4	......
			10	10.8	134	10.3	469	.....	1.68	......	2.49										10.5	757	27.4	70	123	4	Cu	1	bc
			10	11.8	128	11.8	479	.....	1.67	......	2.42										11.5	757	27.5	69	112	4	Cu	1	b
			10	12.8	124	12.3	488	.....	1.65	......	2.35										12.5	757	27.6	66	123	4	Cu	2	b
			10	13.8	136	13.3	466	.....	1.68	......	2.50										13.5	757	27.7	65	134	3	......	0	b
			10	14.8	146	14.3	447	.....	1.70	......	2.64										14.5	756	26.3	70	134	3	......	0	b
			10	15.8	128	15.2	472	.....	1.71	......	2.51										15.5	756	26.0	74	123	3	......	0	b
			10	16.8	93	16.3	471	.....	1.75	......	2.58										16.5	755	26.3	72	123	3	......	0	b
			10	17.8	107	17.2	476	.....	1.76	......	2.57										17.5	756	25.8	76	123	3	Ci	3	b
			10	18.7	109	18.1	485	.....	1.68	......	2.41										18.5	756	25.3	75	123	3	Cu	2	......
			10	19.8	117	19.1	520	.....	1.63	......	2.18										19.5	757	25.4	76	123	3	......	1	b
			10	20.8	98	20.2	490	.....	1.68	......	2.38										20.5	757	25.2	81	123	4	......	3	b
			10	21.8	109	21.2	429	.....	1.62	......	2.62										21.5	757	25.2	81	123	4	......	3	b
			10	22.8	100	22.2	435	.....	1.62	......	2.59										22.5	757	25.2	81	123	4	......	4	b
			10	23.8	107	23.2	435	.....	1.57	......	2.51										23.5	757	25.1	81	112	4	......	1	b
			11	0.8	94	0.3	422	.....	1.55	......	2.55										0.5	757	25.2	81	112	4	......	2	bc
			11	1.7	98	1.2	411	.....	1.55	......	2.62										1.5	757	25.3	76	123	4	......	2	bc
			11	2.8	107	2.1	414	.....	1.56	......	2.62										2.5	757	25.2	79	123	4	......	2	bc
			11	3.8	102	3.1	417	.....	1.56	......	2.60										3.5	757	25.4	78	123	4	......	3	bc
			11	4.8	119	4.2	411	.....	1.51	......	2.55										4.5	757	25.4	78	123	4	......	3	bc
			11	5.9	135	5.1	417	.....	1.50	......	2.50										5.5	757	25.5	76	123	4	......	9	o
			11	6.8	144	6.2	423	.....	1.57	......	2.58										6.5	757	25.7	77	123	4	Cu, Fr-Cu	9	o
			11	7.8	144	7.2	407	.....	1.55	......	2.65										7.5	757	26.2	78	123	4	Ci, Cu	9	c
7.6 S	268.7		12	10.8	198	10.7	302	244	1.27	0.99	2.92	2.82	14.9	5.0							11.2	761	28.6	73	156	5	Fr-Cu	2	b
6.4 S	270.0		13	11.1	207	11.0	365	283	1.18	0.78	2.24	1.91	13.6	4.5							11.7	760	27.5	79	134	4	Cu, A-St	9	c
5.4 S	271.9		14	11.6	171	11.6	399	295	1.38	1.07	2.40	2.52	14.0	4.7							11.5	759	28.2	72	145	6	Cu	2	b
3.7 S	273.6		15	10.6	161	11.6	.....	.....	1.67	1.15											11.8	759	27.7	78	99	4	Cu	4	bc
2.2 S	274.4		16	10.7	174	10.8	428	304	1.34	0.92	2.30	2.10	13.1	4.4							11.7	759	27.9	77	121	3	Cu	4	bc
1.3 S	275.2		17	10.4	145	10.4	359	287	1.38	0.98	2.67	2.37	11.4	3.8							11.2	759	28.0	77	132	4	Cu	4	bc
0.7 N	277.5		18	8.8	162	8.3	425	.....	1.40	......	2.29										8.5	757	25.0	87	154	3	Cu	5	bc
			18	9.8	170	9.3	397	.....	1.24	......	2.17										9.5	756	25.3	84	154	3	Cu	7	......
			18	10.8	177	10.3	381	.....	1.19	......	2.17										10.5	757	26.2	83	142	4	Cu	4	b
			18	11.8	176	11.2	417	.....	1.27	......	2.12										11.5	756	26.8	78	154	4	Cu	3	b
			18	12.8	170	12.1	400	.....	1.27	......	2.20										12.5	756	27.0	80	154	4	Cu	3	b
			18	13.8	160	13.2	386	.....	1.07	......	1.92										13.5	755	27.0	77	154	3	Ci	1	b
			18	14.8	145	14.5	389	.....	1.30	......	2.32										14.5	754	26.8	79	154	3	Cu	2	b
			18	15.8	149	15.4	458	.....	1.23	......	1.85										15.5	754	26.8	79	165	3	Ci	1	b
			18	16.8	124	16.2	466	.....	1.13	......	1.68										16.5	755	25.6	83	165	3	Ci	1	b
			18	17.8	129	17.2	461	.....	0.73	......	1.10										17.5	754	25.2	81	199	3	Ci	2	b
			18	18.8	136	18.2	546	.....	0.77	......	0.98										18.5	755	24.5	86	187	3	Ci-Cu	2	......
			18	19.8	156	19.3	528	.....	0.85	......	1.13										19.5	755	24.5	86	187	3	Ci	1	b
			18	20.8	189	20.3	602	.....	0.95	......	1.10										20.5	756	24.5	86	187	3	Ci	2	b
			18	21.8	128	21.3	585	.....	0.85	......	1.01										21.5	756	24.2	89	187	4	Ci	5	bc
			18	22.8	136	22.3	494	.....	0.81	......	1.14										22.5	756	24.0	90	187	4	Ci	5	bc
			18	23.8	140	23.3	433	.....	0.84	......	1.35										23.5	756	23.9	90	187	4	......	9	o
			19	0.8	160	0.2	378	.....	0.76	......	1.40										0.5	755	24.0	90	187	4	......	8	bc

FINAL RESULTS OF OCEAN ATMOSPHERIC-ELECTRIC OBSERVATIONS ON THE CARNEGIE, 1915–1921—*Continued.*

CRUISE V, PACIFIC OCEAN, 1917–1918—*Concluded.*

Lat.	Long. E. of Gr.	Date	Potential gradient L. M. T.	Potential gradient P	L. M. T.	Ionic content n_+	Ionic content n_-	Conductivity λ_+	Conductivity λ_-	Ionic mobility k_+	Ionic mobility k_-	Current-density, i	Current-density, i	Penetrating radiation L. M. T.	Penetrating radiation B	Radioactive content, Ionization L. M. T.	Radioactive content, Ionization q_0	Radioactive content, Ionization ΔT	Q	Meteorological data L. M. T.	Pressure	Temp. Cent.	Rel. hu.	Wind True dir.	Wind Force	Clouds Kind	Clouds Am't	Weather
°	°	*1918*	*h*	$\left(\frac{v}{m}\right)$	*h*	$\left(\frac{ions}{cc}\right)$		($ESU\times10^{-4}$)		$\left(\frac{cm/s}{v/cm}\right)$		($ESU\times10^{-7}$)	$\left(\frac{a\times10^{-16}}{cm^2}\right)$	*h*	$\left(\frac{ions/cc}{s}\right)$	*h*	$\left(\frac{ions/cc}{s}\right)$	*m*	*	*h*	*mm*	°	*p. ct.*	°				
0.7 N	277.5	Apr 19	1.7	155	1.1	386	.....	0.96	.....	1.73	.....	.....	.....	.....	.....	.....	.....	.....	.....	1.5	755	24.0	89	187	3	.....	8	bc
		19	2.8	151	2.2	367	.....	0.76	.....	1.44	.....	.....	.....	.....	.....	.....	.....	.....	.....	2.5	755	23.9	89	187	3	.....	5	bc
		19	3.8	153	3.1	348	.....	0.70	.....	1.40	.....	.....	.....	.....	.....	.....	.....	.....	.....	3.5	755	23.8	90	187	3	.....	8	bc
		19	4.8	146	4.1	313	.....	0.75	.....	1.66	.....	.....	.....	.....	.....	.....	.....	.....	.....	4.5	755	23.8	90	187	3	.....	8	bc
		19	5.7	146	5.1	324	.....	0.70	.....	1.50	.....	.....	.....	.....	.....	.....	.....	.....	.....	5.5	756	23.7	92	187	3	.....	4	bc
		19	6.8	176	6.2	336	.....	0.47	.....	0.97	.....	.....	.....	.....	.....	.....	.....	.....	.....	6.5	756	23.7	92	210	3	Cu-Nb	7	bc
		19	7.8	210	7.2	290	.....	0.63	.....	1.51	.....	.....	.....	.....	.....	.....	.....	.....	.....	7.5	757	24.7	88	199	3	Cu-Nb	7	bc
2.4 N	279.9	20	10.0	120	9.9	330	269	1.13	0.95	2.38	2.45	8.3	2.8	.....	.....	.....	.....	.....	.....	10.3	759	26.5	75	163	3	Cu, Ci	5	c
3.4 N	280.7	21	10.3	176	10.3	411	365	1.13	0.97	1.91	1.84	12.3	4.1	.....	.....	11.0	2.12	2.8	0.9	10.7	759	27.0	79	242	3	Cu	1	b
5.1 N	281.4	22	10.7	73	10.7	627	621	1.18	1.60	1.31	1.79	6.8	2.3	.....	.....	11.5	3.69	2.2		11.3	760	26.3	86	219	3	A-St, Cu-Nb	8	cqr
Balboa, Canal Zone																												

CRUISE V, ATLANTIC OCEAN, 1918.

Lat.	Long. E. of Gr.	Date	Potential gradient L. M. T.	Potential gradient P	L. M. T.	Ionic content n_+	Ionic content n_-	Conductivity λ_+	Conductivity λ_-	Ionic mobility k_+	Ionic mobility k_-	Current-density, i	Current-density, i	Penetrating radiation L. M. T.	Penetrating radiation B	Radioactive content, Ionization L. M. T.	Radioactive content, Ionization q_0	Radioactive content, Ionization ΔT	Q	Meteorological data L. M. T.	Pressure	Temp. Cent.	Rel. hu.	Wind True dir.	Wind Force	Clouds Kind	Clouds Am't	Weather
°	°	*1918*	*h*	$\left(\frac{v}{m}\right)$	*h*	$\left(\frac{ions}{cc}\right)$		($ESU\times10^{-4}$)		$\left(\frac{cm/s}{v/cm}\right)$		($ESU\times10^{-7}$)	$\left(\frac{a\times10^{-16}}{cm^2}\right)$	*h*	$\left(\frac{ions/cc}{s}\right)$	*h*	$\left(\frac{ions/cc}{s}\right)$	*m*	*	*h*	*mm*	°	*p. ct.*	°				
Cristobal, Canal Zone																												
11.6 N	280.4	May 13	10.7	107	10.8	.....	.....	1.86	1.50	.....	.....	12.0	4.0	.....	.....	11.4	2.49	2.7		11.3	760	28.7	77	72	4	Cu	2	b
13.4 N	280.2	14	10.8	100	10.8	380	326	1.42	1.46	2.60	3.11	9.6	3.2	.....	.....	11.4	†0.59	4.3		11.2	761	28.9	73	83	5	Cu	4	bc
14.0 N	279.8	15	10.8	117	10.9	376	302	1.22	1.07	2.26	2.46	8.9	3.0	.....	.....	11.3	1.37	2.6		11.3	760	29.5	70	49	4	Cu	4	bc
15.9 N	278.5	16	11.1	133	10.8	448	357	1.68	1.48	2.60	2.88	14.0	4.7	.....	.....	11.6	3.48	2.8		11.5	762	29.3	70	60	4	Fr-Cu	3	b
17.8 N	277.5	17	10.4	133	10.1	482	360	1.86	1.60	2.68	3.09	15.3	5.1	.....	.....	10.8	1.57	3.3		11.8	763	30.2	67	60	3	Cu	3	b
20.0 N	276.3	18	11.2	169	10.7	318	274	1.13	0.93	2.47	2.35	11.6	3.9	.....	.....	.....	.....	.....		11.5	763	29.9	69	60	3	Cu	3	b
21.2 N	274.8	19	10.6	122	10.3	311	236	1.04	0.80	2.32	2.35	7.4	2.5	.....	.....	11.1	3.11	2.7		11.1	762	29.5	67	60	3	Cu	1	b
23.4 N	273.7	20	10.4	114	10.4	417	300	1.28	1.02	2.13	2.36	8.7	2.9	.....	.....	.....	.....	.....		10.8	763	28.4	64	72	3	Cu	3	b
23.5 N	274.6	21	11.1	131	11.0	452	322	1.55	1.23	2.38	2.65	12.1	4.0	.....	.....	11.6	0.66	4.3		11.5	765	28.4	68	84	4	Cu	3	b
23.6 N	276.2	22	8.7	133	8.2	575	.....	1.73	.....	2.09	.....	.....	.....	.....	.....	.....	.....	.....		8.5	763	28.0	77	49	4	Cu	4	bc
		22	9.7	123	9.3	597	.....	1.65	.....	1.92	.....	.....	.....	.....	.....	.....	.....	.....		9.5	763	28.0	77	49	5	Cu	3	bc
		22	10.7	164	10.3	496	.....	1.47	.....	2.06	.....	.....	.....	.....	.....	.....	.....	.....		10.5	761	28.0	75	49	5	Cu	6	bc
		22	11.7	133	11.2	442	.....	1.40	.....	2.20	.....	.....	.....	.....	.....	.....	.....	.....		11.5	761	27.8	77	49	5	Cu	3	bc
		22	12.8	134	12.2	483	.....	1.76	.....	2.53	.....	.....	.....	.....	.....	.....	.....	.....		12.5	760	28.3	74	49	5	Cu	3	bc
		22	13.7	138	13.2	531	.....	1.75	.....	2.29	.....	.....	.....	.....	.....	.....	.....	.....		13.5	760	28.0	76	49	5	Cu	3	bc
		22	14.8	138	14.3	468	.....	1.34	.....	1.99	.....	.....	.....	.....	.....	.....	.....	.....		14.5	760	28.0	73	49	5	Cu	2	b
		22	15.8	115	15.4	411	.....	1.13	.....	1.91	.....	.....	.....	.....	.....	.....	.....	.....		15.5	759	26.7	79	49	5	Cu, Ci	8	bcs
		22	16.8	113	16.4	494	.....	1.56	.....	2.19	.....	.....	.....	.....	.....	.....	.....	.....		16.5	758	26.2	82	49	5	Cu, Ci	8	o
		22	17.8	104	17.2	447	.....	1.22	.....	1.89	.....	.....	.....	.....	.....	.....	.....	.....		17.5	758	26.2	79	72	5	Ci-Cu	9	oc
		22	18.8	99	18.2	503	.....	1.31	.....	1.81	.....	.....	.....	.....	.....	.....	.....	.....	2.2	18.5	759	26.2	80	72	5	Cu	3	bc
		22	[1]19.7	74	19.3	488	.....	1.62	.....	2.30	.....	.....	.....	.....	.....	.....	.....	.....		19.5	759	26.2	82	72	5	Cu	3	bc
23.9 N	277.1	23	10.8	107	10.3	410	295	1.47	1.06	2.49	2.49	9.0	3.0	.....	.....	11.4	3.85	2.1		11.2	764	27.0	78	60	5	Cu, A-St	7	bc

*Curie×10^{-16} per cubic centimeter. †Not used in the computation of Q, irregular. [1] Observations stopped on account of spray and heavy pitching.

25.1 N	280.2	May	26	11.0	157	10.9	.....	.....	0.93	0.70	.....	.....	8.5	2.8	.....	.....	11.5	1.30	2.5		11.4	767	27.5	75	92	5	Cu, Cu-Nb	4	bc
28.8 N	280.2		27	11.1	139	11.2	325	295	0.75	0.62	1.60	1.46	6.3	2.1	.....	.....	11.6	1.53	4.4		11.7	767	27.0	69	68	3	Ci, Cu	4	bc
30.6 N	281.0		28	11.2	149	11.3	307	221	0.86	0.73	1.95	2.30	7.9	2.6	.....	.....	.....	.....	.....		12.0	769	27.5	62	112	1	.....	0	b
31.1 N	281.6		28	20.8	134	20.2	327	.....	0.93	.....	1.97	.....	.....	.....	.....	.....	.....	.....	.....		20.5	765	24.3	72	134	2	Cu	4	bc
			28	21.8	129	21.4	598	.....	0.81	.....	0.94	.....	.....	.....	.....	.....	.....	.....	.....		21.5	764	23.2	85	134	2	Cu	4	bc
			28	22.8	123	22.3	249	.....	0.86	.....	2.40	.....	.....	.....	.....	.....	.....	.....	.....		22.5	764	24.0	71	134	2	Cu	3	b
			28	23.7	125	23.2	264	.....	0.92	.....	2.42	.....	.....	.....	.....	.....	.....	.....	.....		23.5	764	24.0	75	146	2	Cu	3	b
			29	0.8	148	0.2	253	.....	0.95	.....	2.61	.....	.....	.....	.....	.....	.....	.....	.....		0.5	764	24.0	72	146	2	Cu	6	bc
			29	1.7	103	1.1	296	.....	0.92	.....	2.16	.....	.....	.....	.....	.....	.....	.....	.....		1.5	764	23.9	71	146	1	Cu	3	.....
			29	2.8	113	2.1	261	.....	0.97	.....	2.58	.....	.....	.....	.....	.....	.....	.....	.....		2.5	764	23.7	71	146	1	Cu	2	b
			29	3.8	124	3.1	278	.....	0.95	.....	2.37	.....	.....	.....	.....	.....	.....	.....	.....		3.5	764	23.5	74	146	1	Ci, Cu	3	bc
			29	4.7	113	4.1	.....	.....	0.96	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....		4.5	764	23.6	74	146	1	Cu	1	b
			29	5.7	117	5.3	.....	.....	0.90	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....		5.5	764	24.0	74	146	1	Cu	3	bc
			29	6.8	151	6.4	277	.....	0.84	.....	2.11	.....	.....	.....	.....	.....	.....	.....	.....		6.5	765	24.5	70	146	1	Ci-Cu	6	bc
			29	7.7	114	7.2	277	.....	0.87	.....	2.18	.....	.....	.....	.....	.....	.....	.....	.....		7.5	765	25.2	71	146	1	Cu	6	bc
31.8 N	282.3		30	11.3	201	11.5	244	248	0.82	0.68	2.34	1.90	10.0	3.3	.....	.....	11.8	1.33	3.1		11.7	766	28.0	63	291	2	Ci-St, Fr-Cu	1	b
32.6 N	283.9		31	10.6	124	10.7	233	160	0.76	0.60	2.26	2.61	5.6	1.9	.....	.....	11.3	2.78	1.9		11.0	764	27.4	75	311	4	Cu	1	b
33.9 N	285.5	Jun	1	10.9	235	10.7	608	247	0.55	0.41	0.63	1.15	7.5	2.5	.....	.....	11.3	2.96	4.0		11.1	763	28.0	81	.....	0	Cu	0	b
34.4 N	286.1		2	11.6	200	11.7	154	116	0.61	0.44	2.75	2.63	7.0	2.3	.....	.....	.....	.....	.....	1.8	11.8	763	27.1	84	219	3	.....	0	bz
36.1 N	285.3		3	10.9	262	11.0	139	92	0.43	0.36	2.15	2.73	6.9	2.3	.....	.....	11.3	7.99	1.6		11.2	765	24.2	83	354	2	Ci-Cu	2	bz
Washington																													

CRUISE VI, ATLANTIC OCEAN, 1919–1920.

°	°	1919		h	$\left(\frac{s}{m}\right)$	h	$\left(\frac{ions}{cc}\right)$		$(ESU \times 10^{-4})$		$\left(\frac{cm/s}{v/cm}\right)$		$(ESU \times 10^{-7})$	$\left(\frac{s \times 10^{-18}}{cm^2}\right)$	h	$\left(\frac{ions/cc}{s}\right)$	h	$\left(\frac{ions/cc}{s}\right)$	m	*	h	mm	°	p.d.	°				
Washington																													
38.9 N	284.1	Oct	19	8.3	253	8.8	184	118	.....	.....	.....	.....	.....	.....	15.3	3.79	13.8	†11.77	5.5	.....	9.6	770	16.0	68	39	3	.....	.....	b
35.6 N	286.2		20	9.3	44	8.9	.....	446	.....	.....	.....	.....	.....	.....	.....	.....	10.9	7.43	3.9		12.0	767	23.5	62	61	6	.....	10	o
			20	.....	.....	9.7	390	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....		.....	.....	.....	.....	.....	.....	.....	.....	.....
			20	.....	.....	15.9	.....	156	.....	.....	.....	.....	.....	.....	15.2	3.04	.....	.....	.....	9.2	.....	.....	.....	.....	.....	.....	.....	.....	.....
38.4 N	291.6		22	10.2	[1]136	14.8	387	274	.....	.....	.....	.....	.....	.....	12.6	4.63	.....	.....	.....		12.0	765	22.6	83	247	6	.....	.....	cr
38.5 N	295.8		23	9.6	169	13.8	500	510	.....	.....	.....	.....	.....	.....	11.4	6.13	10.1	20.71	3.5		9.9	768	18.7	62	18	5	.....	.....	o
37.7 N	297.6		24	10.2	101	15.7	513	408	.....	.....	.....	.....	.....	.....	14.0	4.96	11.4	11.23	13.8		11.3	767	20.9	66	93	2	.....	.....	odr
36.8 N	298.0		25	9.0	188	13.7	557	400	.....	.....	.....	.....	.....	.....	15.9	2.93	10.2	4.01	15.0		9.4	766	22.0	69	85	6	.....	.....	bc
38.8 N	298.9		26	9.0	208	16.1	538	403	.....	.....	.....	.....	.....	.....	17.0	3.39	.....	.....	.....		9.3	767	22.2	67	112	4	.....	.....	bc
38.9 N	306.4		28	13.7	92	14.7	587	535	.....	.....	.....	.....	.....	.....	13.8	4.06	.....	.....	.....		14.0	763	21.0	80	34	4	.....	.....	bc
38.4 N	309.3		29	9.4	173	8.4	339	368	.....	.....	.....	.....	.....	.....	14.5	2.84	11.5	10.85	1.4		9.6	761	22.5	84	236	6	Cu, Cu-Nb	.....	bcr
38.4 N	316.4	Nov	1	13.6	159	10.6	650	676	.....	.....	.....	.....	.....	.....	16.6	3.68	.....	.....	.....	4.5	12.0	758	14.2	73	314	10	.....	10	od
38.5 N	319.5		2	8.5	167	9.0	685	738	.....	.....	.....	.....	.....	.....	11.9	3.31	10.6	5.33	3.3		8.8	758	15.7	66	325	4	.....	10	o
39.1 N	323.0		4	9.2	157	9.3	885	649	.....	.....	.....	.....	.....	.....	11.5	3.79	10.3	5.41	6.8		9.5	758	16.0	75	21	5	.....	.....	bc
38.9 N	327.4		5	9.5	146	9.9	691	674	.....	.....	.....	.....	.....	.....	12.1	3.67	10.9	4.59	4.7		9.6	742	17.3	77	325	5	.....	.....	bc
38.8 N	329.5		6	9.7	143	13.9	598	535	.....	.....	.....	.....	.....	.....	12.6	4.66	10.3	2.01	5.5		10.0	761	17.7	68	.....	0	.....	10	o
37.3 N	329.8		7	11.4	190	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	12.0	758	18.5	91	79	6	.....	.....	cd
35.6 N	329.7		8	10.2	103	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	12.0	762	20.0	91	147	2	.....	.....	c
35.6 N	331.9		9	11.3	120	14.8	720	.....	.....	.....	.....	.....	.....	.....	17.4	5.90	.....	.....	.....	.....	11.5	762	22.5	85	226	4	.....	9	c
35.2 N	334.1		10	14.6	163	15.6	.....	676	.....	.....	.....	.....	.....	.....	18.4	4.17	16.6	3.29	3.0		16.0	768	20.5	83	25	3	.....	.....	bc
34.2 N	335.8		11	15.9	269	13.5	486	438	.....	.....	.....	.....	.....	.....	19.5	4.56	17.2	3.08	4.3		12.0	768	21.0	83	340	3	.....	.....	bc
33.1 N	338.0		12	15.3	230	.....	.....	.....	.....	.....	.....	.....	.....	.....	16.6	3.65	.....	.....	.....		16.0	756	21.5	87	229	5	.....	.....	o
30.3 N	340.2		13	15.7	143	16.6	728	428	.....	.....	.....	.....	.....	.....	17.6	4.09	11.8	2.01	6.3	3.5	12.0	750	21.8	73	263	5	.....	.....	cqu
27.4 N	340.7		14	8.8	93	9.9	786	546	.....	.....	.....	.....	.....	.....	19.3	3.34	17.5	1.32	4.3		15.1	757	23.0	78	275	3	.....	.....	b
25.6 N	340.6		15	10.0	105	9.0	870	694	.....	.....	.....	.....	.....	.....	16.3	3.86	14.2	3.15	4.2		9.0	760	21.0	80	50	3	.....	.....	b
25.2 N	340.4		16	10.1	90	9.0	752	667	.....	.....	.....	.....	.....	.....	.....	.....	12.8	1.19	5.6		9.8	764	22.3	83	151	2	.....	.....	bcr
24.8 N	340.5		17	9.6	[2]77	9.0	589	360	.....	.....	.....	.....	.....	.....	17.1	4.98	.....	.....	.....	.....	10.0	764	23.2	90	140	2	.....	.....	cr
22.1 N	340.4		18	8.8	143	9.4	610	447	.....	.....	.....	.....	.....	.....	12.1	4.18	10.8	39.02	2.7		10.1	763	25.0	75	83	4	.....	.....	o
19.2 N	341.1		19[3]	8.8	330	9.4	250	.....	.....	.....	.....	.....	.....	.....	16.0	4.58	11.5	0.00	.....		9.2	764	26.0	68	94	5	.....	.....	cz
16.5 N	341.9		20[3]	9.5	212	12.5	151	92	.....	.....	.....	.....	.....	.....	16.8	5.22	.....	.....	.....		9.9	761	25.5	55	72	4	.....	.....	bcz

* Curie $\times 10^{-18}$ per cubic centimeter.
† Not used in the computation of Q, irregular.
[1] Observations interrupted by rain.
[2] Main engine running; potential gradient was zero in middle of set.
[3] Air full of fine red sand dust from the Sahara harmattan.

FINAL RESULTS OF OCEAN ATMOSPHERIC-ELECTRIC OBSERVATIONS ON THE CARNEGIE, 1915–1921—*Continued.*

CRUISE VI, ATLANTIC OCEAN, 1919–1920—*Continued.*

Lat.	Long. E. of Gr.	Date	Potential gradient L. M. T.	Potential gradient P	Ionic content L. M. T.	Ionic content n_+	Ionic content n_-	Conductivity λ_+	Conductivity λ_-	Ionic mobility k_+	Ionic mobility k_-	Current-density, i	Current-density, i	Penetrating radiation L. M. T.	Penetrating radiation R	Radioactive content L. M. T.	Ionization q_0	Ionization ΔT	Q	Meteorological data L. M. T.	Pressure	Temp. Cent.	Rel. hm.	Wind True dir.	Wind Force	Clouds Kind	Clouds Am't	Weather
°	°	*1919*	h	$\left(\frac{v}{m}\right)$	h	$\left(\frac{ions}{cc}\right)$		$(ESU\times10^{-4})$		$\left(\frac{cm/s}{v/cm}\right)$		$(ESU\times10^{-7})$	$\left(\frac{a\times10^{-16}}{cm^2}\right)$	h	$\left(\frac{ions/cc}{s}\right)$	h	$\left(\frac{ions/cc}{s}\right)$	m	*	h	mm	°	p. ct.	°				
15.2 N	342.5	Nov 21[1]	9.2	[2]114	12.5	90	57	...	...	...	...	...	...	17.4	5.05	...	...	...		8.8	762	25.8	48	117	3	...	...	bcz
14.6 N	342.5	22[1]	10.1	[2]84	8.9	483	381	...	...	...	...	...	...	11.0	4.96	...	...	...	29.3	10.5	762	28.5	35	73	3	...	...	bcz
Dakar																												
12.9 N	342.4	27	9.6	34	9.9	1338	1098	...	...	...	...	...	...	...	...	...	...	...		9.9	759	27.0	58	4	3	...	0	b
10.5 N	343.1	28	9.5	49	10.0	856	841	1.30	1.61	1.06	1.33	4.8	1.6	16.4	5.05	14.8	32.48	3.5		10.1	758	26.8	60	26	3	...	0	b
9.7 N	343.8	29	9.2	72	9.6	575	534	1.35	1.37	1.63	1.78	6.5	2.2	13.1	4.79	11.0	30.08	2.8		10.4	759	28.0	75	341	1	...	...	bc
8.7 N	344.7	30	9.5	155	10.1	354	317	1.13	0.81	2.22	1.78	...	...	12.8	5.38	11.4	9.86	2.5		9.8	758	29.2	71	341	2	...	...	bc
7.7 N	345.8	Dec 1	9.6	140	10.6	349	362	...	...	...	...	...	...	12.3	4.30	11.3	5.05	2.8	8.2	10.0	758	28.1	72	...	0	...	0	bz
7.2 N	346.7	2	9.9	114	10.6	238	228	0.42	0.60	1.22	1.83	...	...	13.9	4.24	11.8	2.99	3.9		10.2	758	29.5	74	...	0	...	...	bz
6.8 N	346.6	3	9.1	171	10.3	211	201	0.47	0.52	1.55	1.80	...	...	12.0	4.13	11.1	2.79	3.0		9.6	758	30.4	67	...	0	...	...	bc
6.4 N	346.8	4	9.1	149	9.6	206	176	0.66	0.46	2.22	1.82	5.6	1.9	12.1	4.03	11.0	3.36	2.9		9.4	760	27.9	80	274	2	...	...	bc
5.9 N	348.1	5	11.0	134	11.1	409	394	0.57	1.31	0.97	2.31	8.4	2.8	15.8	4.33	14.2	3.22	14.3		11.4	758	28.5	66	184	1	...	...	bc
5.2 N	349.1	6	10.6	131	9.8	375	438	0.66	0.53	1.22	0.84	...	...	15.3	4.10	13.8	1.22	10.1		11.0	758	28.8	73	173	1	...	...	bc
4.8 N	350.5	7	9.5	137	9.8	315	195	0.81	0.56	1.78	1.99	6.2	2.1	12.2	4.18	10.9	1.89	3.2		9.9	758	28.5	76	162	2	...	...	bc
4.3 N	351.9	8	9.6	77	10.9	277	226	0.79	0.53	1.98	1.63	...	...	...	...	13.9	†3.53	2.8	1.9	9.9	758	27.2	85	61	1	...	...	bc
3.7 N	352.3	9	8.9	131	...	...	...	...	...	...	...	...	...	...	...	...	...	...		9.1	758	27.7	78	174	2	...	...	bc
4.1 N	354.2	10	9.2	120	9.6	230	184	0.66	0.59	1.99	2.23	5.0	1.7	11.9	4.87	10.8	1.35	4.0		9.4	757	27.7	76	163	3	...	...	bc
4.1 N	355.4	11	12.1	157	10.5	276	259	0.76	0.60	1.91	1.61	...	...	12.9	4.22	11.6	1.90	6.8		12.3	756	29.6	72	186	1	...	...	bc
4.1 N	356.3	12	9.7	114	11.3	268	236	0.68	0.57	1.76	1.68	...	...	15.2	5.15	14.4	2.53	11.4		10.0	758	27.6	82	220	2	...	...	b
3.6 N	357.9	13	10.7	112	10.0	218	215	0.71	0.62	2.26	2.00	...	...	12.1	4.81	10.8	2.09	7.2		11.1	758	28.3	80	187	2	...	...	bc
2.9 N	359.3	14	9.8	86	10.4	330	195	0.66	0.69	1.39	2.46	...	...	14.7	4.15	11.3	1.52	8.3		10.0	758	27.3	81	300	2	...	...	o
2.0 N	0.3	15	9.8	74	11.0	...	...	0.89	0.78	...	...	...	...	...	...	...	...	...	...	10.1	758	27.0	84	221	2	...	...	o
1.1 N	1.6	16	8.6	43	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	8.9	758	27.1	80	210	2	...	...	ou
0.1 N	3.7	17	9.3	112	10.8	434	387	1.07	0.76	1.71	1.36	...	...	...	...	...	...	...	...	9.5	758	26.0	78	199	4	...	...	o
1.5 S	5.0	18	11.8	149	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	12.0	759	26.0	82	233	5	...	...	or
0.8 S	3.5	19	...	...	11.1	342	391	0.90	1.12	1.83	1.99	...	...	15.9	4.36	14.6	†3.23	22.5	...	15.8	759	25.5	84	232	2	...	...	o
0.3 S	3.2	20	9.4	149	10.3	443	334	1.03	1.22	1.61	2.54	...	...	12.3	4.03	11.4	0.65	5.3		9.7	759	29.2	72	176	2	...	...	bc
0.5 S	1.7	21	9.8	123	9.9	518	452	1.02	1.55	1.37	2.38	10.5	3.5	11.8	4.39	10.6	0.94	8.3		10.2	760	27.8	77	187	2	...	...	bc
1.2 S	0.2	22	9.9	108	9.4	490	404	1.15	0.86	1.63	1.48	7.2	2.4	12.2	3.29	...	...	...		10.2	760	27.1	79	152	1	...	...	bc
1.9 S	358.1	23	9.2	117	9.8	507	440	1.35	0.90	1.85	1.42	...	...	10.8	4.14	10.4	0.72	11.1		9.5	760	26.3	82	151	3	...	...	bc
3.2 S	356.0	24	9.6	106	9.9	523	450	0.86	0.60	1.14	0.93	5.2	1.7	12.0	4.24	10.7	1.11	7.0	0.7	10.0	760	26.0	82	150	4	...	...	bc
4.8 S	353.7	25	9.3	108	9.6	534	452	1.50	1.25	1.95	1.92	9.9	3.3	11.4	4.22	10.2	0.63	4.8		9.7	760	25.6	78	148	5	...	...	o
6.8 S	351.3	26	9.4	86	10.4	718	496	1.47	1.12	1.43	1.57	...	...	13.0	4.20	11.8	0.59	7.7		9.7	760	25.1	77	147	5	...	...	o
9.0 S	349.1	27	9.7	88	9.6	655	514	1.52	1.33	1.61	1.80	8.4	2.8	12.6	4.36	11.5	0.94	6.6		9.9	762	23.8	70	146	5	...	...	o
10.9 S	346.9	28	11.5	143	9.4	664	668	1.82	1.34	1.90	1.39	...	...	11.4	3.98	11.2	0.37	8.8		11.7	762	24.0	65	145	5	...	...	co
12.9 S	344.7	29	9.2	159	9.1	706	539	1.22	1.07	1.20	1.38	12.1	4.0	11.0	4.07	9.8	0.25	11.2		9.5	763	24.1	69	145	4	...	...	bc
15.3 S	342.3	30	6.0	120	6.6	799	...	1.87	...	1.63	...	...	...	6.5	3.35	...	...	...	...	6.0	763	...	...	145	4	...	...	b
		30	7.0	111	7.6	761	...	1.79	...	1.63	...	...	...	7.4	4.18	...	...	...	...	7.0	763	...	...	145	4	Cu	...	bc
		30	8.2	91	8.8	746	...	1.78	...	1.66	...	...	...	8.7	5.91	...	...	...	...	8.0	763	23.8	63	145	4	Cu	3	bc
		30	9.2	89	9.9	651	...	1.70	...	1.81	...	...	...	9.7	4.51	...	...	...	...	9.2	763	...	...	134	5	Cu	3	bc
		30	10.3	100	10.9	694	...	1.76	...	1.76	...	...	...	10.7	4.14	...	...	...	...	10.3	763	...	...	122	5	...	0	b
		30	11.4	126	11.9	631	...	1.44	...	1.58	...	...	...	11.8	3.04	...	...	...	...	11.4	762	24.5	65	122	5	...	...	bc

*Curie $\times10^{-12}$ per cubic centimeter. †Not used in the computation of Q, irregular. [1] Harmattan. [2] Main engine running.

15.3 S	342.3	Dec	30	12.3	126										13.1	3.88					12.3	762	24.5	63	122	5		0	b
			30	13.5	90	13.1	685		1.69		1.71				14.1	3.76					13.5	762			122	5			bc
			30	14.4	108	14.1	642								14.9	3.51					14.4	762			122	4			b
			30	15.4	155	15.0	694		1.42		1.42				15.9	3.73					15.4	762			122	4	Cu	1-2	b
			30	16.8	164	16.0	740		1.83		1.71				17.4	3.70					16.8	762	23.0	75	122	4			bc
			30	17.8	148	17.4	635		1.61		1.76				18.5	3.50					17.8	762			122	4			bc
16.3 S	341.3		30	19.2	156	18.6	687		1.91		1.93										19.2	762	22.6	73	122	4			bc
			30	20.3	149	19.9	686		2.02		2.04										20.3	762	22.6	75	134	4			bc
			30	22.2	112	20.9	666		1.49		1.55										22.2	762	22.5	78	134	4			bc
			30	23.4	136	22.8	712		1.89		1.83										23.4	763	22.5	76	134	4			bcru
			31	0.6	121	0.3	652		1.71		1.82				1.1	3.98					0.6	764	22.5	76	134	5			b
			31	1.6	108	1.1	801		1.65		1.43				2.1	3.29					1.6	763	22.6	77	134	5			b
			31	2.7	138	2.2	655		1.71		1.81				3.2	3.52					2.7	762	22.7	78	134	5			bc
			31	3.7	144	3.3	703		1.47		1.46				4.2	3.25					3.7	762	22.8		122	5	Cu–Nb		bc
			31	4.9	148	4.3	683		1.35		1.37				5.4	2.91					4.9	762			134	5	Cu–Nb		bc
			31	6.0	158	5.5	688		1.46		1.47										6.0	762	23.6	73	122	5	Cu	3	bc
17.3 S	340.8		31	10.8	151	9.7	639	591	1.83	1.17	1.99	1.37									10.8	764	25.7	65	122	5			b
		1920																											
19.1 S	338.6	Jan	1	10.0	129	10.5	736	577	1.80	1.57	1.70	1.89	14.5	4.8	12.1	3.94	11.2	0.60	6.5		10.2	764	26.7	67	112	4			bc
20.6 S	337.0		2	10.1	123	9.9	601	532	1.30	1.02	1.50	1.32	9.5	3.2	11.7	4.13	10.8	0.57	7.6		10.4	764	27.5	60	135	4			bc
22.1 S	335.5		3	9.2	126	9.9	603	468	1.27	1.54	1.46	2.28			11.4	4.01	10.6	0.27	9.7		9.6	765	27.5	63	90	3			bc
23.7 S	333.8		4	9.5	108	9.9	735	615	1.66	1.55	1.57	1.75	11.6	3.9	12.0	4.29	10.4	0.35	8.2		9.8	765	25.8	64	68	3			bc
24.8 S	333.0		5	9.7	166	9.9	752	675	1.53	1.28	1.42	1.32	15.5	5.2	11.6	4.04	10.4	0.21	12.8	0.8	10.0	764	24.8	70	2	3			b
26.4 S	330.8		6[1]	9.6	120	10.2	651	591	1.59	1.25	1.70	1.47			12.4	4.91	10.9	0.34	10.0		9.9	759	25.8	79	318	5			bc
31.0 S	321.8		10	11.7	245	10.3	749	597	1.83	1.50	1.69	1.74			12.7	4.44	11.4	[2]2.68	[2]9.9		11.8	757	27.0	75	347	2			bc
32.6 S	319.7		11	9.9	145	10.4	880	536	1.52	1.13	1.20	1.46	12.8	4.3	15.5	5.33					10.4	757	23.2	86	282	4			bc
33.0 S	318.0		12	9.7	251	10.6	395	389	0.61	0.67	1.07	1.20					14.3	1.14	4.8		10.2	760	22.8	60	148	0-1			bc
33.8 S	316.1		13	7.4	163	8.8	455		0.74		1.13										7.4	757			341	3			c
			13	9.3	232	9.9	362		0.68		1.31										9.5	757	23.9	85	341	3	Ci	3	bc
			13	10.4	251	10.9	353		0.81		1.59										10.4	757			307	3	Ci–Cu	4	bc
			13	11.4	249	11.8	328		0.79		1.67										11.6	756	24.6	83	307	3	Ci–Cu	3	bc
			13	12.5	262	13.3	327		0.71		1.51										12.5	757			307	3	Ci–Cu	1	b
			13	13.8	274	14.3	368		0.75		1.42										13.8	757			307	2	Ci–Cu	2	b
			13	14.7	274	15.3	370		0.87		1.63										14.7	756			296	2	Ci–Cu	4	bc
			13	15.8	243	16.4	341		0.78		1.59										16.0	756	24.5	83	262	2	Ci–Cu	5	bc
			13	16.8	302	17.3	838		1.13		0.93										16.8	755			251	2	Cu	8	c
			13	17.8	159	18.2	563		1.00		1.23										17.8	755			251	2	Ci–Cu	8	c
33.8 S	315.8		13	18.9	172	19.6	645		1.07		1.15										19.1	756	22.5	82	251	2			bc
			13	20.1	94	20.7	554		0.94		1.18										20.0	756	21.8	88	251	2			bc
			13	21.5	137	22.4	457		0.74		1.12										21.8	756	21.6	89	194	2			bc
			13	23.0	264	23.7	329		0.59		1.24										23.2	755	21.0	81	194	1			bc
			13	24.4	354	24.0	327		0.88		1.87										24.0	755	20.5	92		0			bc
			14	1.6	290	2.1	277		0.65		1.63										1.6	755				0			b
			14	2.8	268	3.5	303		0.62		1.42										3.1	755	20.3	92	330	1			b
			14	4.0	212	4.6	311		1.24		2.77										4.0	754	20.8	89	307	2			b
			14	5.2	245	5.8	357		0.79		1.54										5.2	754			296	3			b
			14	6.2	171	7.0	427		1.00		1.63										6.5	755	20.5	89	288	3			b
			14	7.4	206	7.9	361		1.00		1.92										7.4	753			288	5		0	b
33.6 S	312.1		15	9.1	143	10.1	622	500	1.41	1.09	1.57	1.51					11.7	0.83	7.8		9.5	758	18.9	55	198	4			bc
34.0 S	310.1		16	9.9	137	10.0	540	503	1.09	1.06	1.40	1.46	9.8	3.3			11.3	0.40	7.6		10.2	760	22.4	66	358	5			cu
34.6 S	306.2		17[1]	10.8	174	9.4	390	412	0.57	0.60	0.99	1.01									11.2	756	23.6	84					s
Buenos Aires																				0.2									
37.3 S	305.2	Feb	24	10.4	134	11.4	631	343	0.97	0.59	1.07	1.19			14.7	4.90					10.8	763	20.5	85	59	3	St–Cu		bc
39.3 S	307.5		25[3]	11.1	148	11.0	515	461	0.99	1.04	1.33	1.57	10.0	3.3	14.3	4.64	12.3	[4]5.23	[4]5.2		11.5	757	20.8	89	282	5	St–Cu		cur
40.5 S	310.1		26	10.0	100	10.2	797	700	1.27	1.14	1.10	1.13	8.0	2.7	12.6	4.07	11.5	1.81	3.9		10.8	756	17.0	72	179	5	Cu	5	bc
41.4 S	311.8		27	9.7	134	9.8	732	578	1.09	1.19	1.04	1.43	10.2	3.4	12.3	4.56	11.4	0.40	8.6		10.1	757	17.5	75	291	4			b

[1] Heavy rain during previous night. [2] For these observations Q = 3.3, computed separately since the decay curve indicated possible land-effect, as wind was off shore. [3] Rain before these observations. [4] For these observations the value of Q = 19.6, which was not used in the mean, since the shape of the decay curve showed a possible land-effect.

FINAL RESULTS OF OCEAN ATMOSPHERIC-ELECTRIC OBSERVATIONS ON THE CARNEGIE, 1915–1921—*Continued.*

CRUISE VI, ATLANTIC OCEAN, 1919–1920—*Continued.*

Lat.	Long. E. of Gr.	Date	Potential gradient L. M. T.	Potential gradient P	L. M. T.	Ionic content n_+	Ionic content n_-	Conductivity λ_+	Conductivity λ_-	Ionic mobility k_+	Ionic mobility k_-	Current-density, i	Current-density, i	Penetrating radiation L. M. T.	Penetrating radiation B	Radioactive content L. M. T.	Radioactive content Ionization q_0	Radioactive content Ionization ΔT	Q	Meteorological data L. M. T.	Pressure	Temp. Cent.	Rel. hm.	Wind True dir.	Wind Force	Clouds Kind	Clouds Am't	Weather
°	°	*1920*	*h*	$\left(\frac{v}{m}\right)$	*h*	$\left(\frac{ions}{cc}\right)$		($ESU\times10^{-4}$)		$\left(\frac{cm/s}{v/cm}\right)$		($ESU\times10^{-7}$)	$\left(\frac{a\times10^{-18}}{cm^2}\right)$	*h*	$\left(\frac{ions/cc}{s}\right)$	*h*	$\left(\frac{ions/cc}{s}\right)$	*m*	*	*h*	*mm*	°	*p. ct.*	°				
43.9 S	313.6	Feb 28	10.0	264	9.9	270	204	0.36	0.35	0.93	1.19	6.2	2.1	12.6	4.36					10.2	748	15.4	92	313	3	St, A-Cu	9	corf
45.9 S	323.0	Mar 1	14.7	98	13.0	644	543	1.29	1.20	1.39	1.53			14.9	4.58					13.7	749	9.0	79	227	7		10	or
45.0 S	327.3	2	10.4	104	9.8	588		2.25		2.66				9.8	4.07					10.6	761	8.3	76	202	5	Cu		bc
		2	11.4	106	11.0	559		1.96		2.43				10.9	4.13					11.4	761			202	5	Cu	6	bc
		2	12.5	98	12.0	594		1.84		2.15				12.0	4.01					12.5	762	8.3	81	202	5			bc
		2	13.9	101	13.4	739		1.71		1.61				13.3	4.01					14.2	762	9.0	82	202	5			bc
		2	15.0	123	14.5	661		1.76		1.85				14.4	3.82					15.0	762			202	5	Ci-Cu	7	bc
		2	16.6	125	16.0	562		1.78		2.20				15.7	3.79					16.6	763	8.8	80	224	5	Ci-Cu	3	bc
		2	17.8	119	17.3	714		1.88		1.83				17.1	3.94					17.8	763			202	5	Ci-Cu		c
		2	[1]19.1	113	18.5	676		1.96		2.01				18.5	4.49					19.1	764			202	5	St-Cu	9	co
		2			20.2	696		1.47		1.47										20.2	765	7.5	74	202	5			o
		2			21.5	731		1.18		1.12										21.5	765			202	4			o
		2			22.7	660		1.52		1.60										22.7	766			202	3			o
		2			23.8	833		1.85		1.54										23.8	767	6.5	80	202	2			o
		3			1.2	852		1.45		1.18				1.1	4.43					1.2	767			188	2			o
		3			2.3	812		1.25		1.07				2.2	4.24					2.3	767			256	2			o
		3			3.5	710		1.18		1.16				3.4	4.96					3.5	767			256	2			o
		3			4.5	698		1.15		1.14				4.5	4.07					4.5	767	7.5	70	256	2			o
		3			5.7	764		1.10		1.00				5.6	4.18					5.7	768			256	2			bc
		3			6.9	931		1.15		0.86				6.8	3.82					6.7	767			301	3			bc
		3			7.8	824		1.30		1.09										7.8	767	7.8	75	312	3			bc
		3			9.2	834		1.10		0.92										9.2	767			324	3			bc
45.8 S	334.6	4	10.5	92	10.7	586	505	1.31	1.11	1.55	1.53	7.4	2.5	14.0	4.35	11.6	0.49	7.8		10.8	770	10.7	87	310	5	St, Cu	10	o
44.3 S	339.7	5	10.2	114	10.5	550	381	1.22	0.92	1.54	1.68	8.1	2.7	12.5	4.53	11.8	†0.11	11.7		10.6	773	11.8	86	293	4		0	b
42.4 S	344.3	6	11.1	80	10.6	466	420	1.12	0.93	1.67	1.54	5.5	1.8	12.7	4.12	12.0	0.12	10.4		10.4	770	12.8	86	282	5	St, Cu	0	o
40.9 S	348.2	7	11.1	94	10.7	342	311	0.91	0.69	1.85	1.56	5.0	1.7	13.8	4.46	12.1	0.51	4.6		11.4	765	13.4	89	267	4	St	10	o
40.2 S	350.0	8[2]	11.0	183	11.1	479	454	1.27	1.04	1.84	1.59	14.1	4.7	14.1	4.45	12.3	0.32	8.6		11.6	762	14.7	89	154	1	St	10	o
38.9 S	351.7	9	10.7	112	10.6	706	595	1.50	1.26	1.47	1.47	10.3	3.4	12.9	4.12	11.8	0.52	7.2		11.1	763	14.8	77	108	3	Cu	7	bc
37.0 S	353.0	10	11.7	123	12.0	832	635	1.45	1.13	1.21	1.24	10.6	3.5	15.5	4.53	15.2	[3]5.93	[3]4.2		11.8	760	17.5	91	119	3	St	9	o
36.2 S	353.9	11	11.8	145	10.6	474	349	0.99	0.94	1.45	1.87			14.0	3.73	12.6	0.53	7.6		11.4	761	18.6	95	287	1	Fr-St	5	bcf
35.8 S	356.1	12	9.8	95	11.4	956	746	1.73	1.25	1.26	1.17			15.1	4.13	14.3	1.12	4.2	1.1	10.6	761	20.0	91	6	3	Fr-Cu	10	o
		12	11.2	62																12.0	760	21.3	79	6	4	St-Cu	1	b
		12	16.9	94																16.0	759	20.0	90	6	4	Cu, Ci-Cu	4	bc
35.1 S	0.0	13	10.7	98	11.7	685	671													12.0	757	21.3	93	298	5			bcr
		13	11.3	98																11.3				309	5	St-Cu, Fr-Cu		bc
		13	16.2	100																16.0	759	21.2	80	253	4	Cu	9	c
33.0 S	2.0	14	10.0	87	10.1	752	375	1.42	1.48	1.31	2.74	8.4	2.8	13.9	4.22	12.3	0.72	7.7		10.3	766	20.0	64	196	3			b
		14	10.9	79																						Fr-Cu	0-1	b
		14	16.8	63																16.0	765	21.5	61	174	2	Cu	1	b
32.3 S	2.5	15	9.5	164	10.1	410	307	0.72	0.91	1.22	2.06			12.3	4.12	11.4	0.17	7.9		9.9	768	21.0	60	286	1	Fr-Cu	1	b
		15	10.2	123																10.2	768	21.0	60	288	1	Fr-Cu	1	b
31.0 S	3.4	16	6.5	72	7.2	680		1.43		1.58				7.2	3.72					6.5	769	19.0		152	1	St-Cu	9	co

* Curie$\times10^{-18}$ per cubic centimeter. † Not used in the computation of Q, irregular. [1] Lamp out of order after this set. [2] Gough Island distant 5 miles. [3] Same as footnote 4, p. 243, except that $Q = 18.6$.

31.0 S	3.4	Mar	16	7.6	163	8.4	648		1.64		1.76				8.4	3.70					7.8	770	19.5	74	152	2	St-Cu	8-9	o
			16	8.9	60	9.4	658		1.46		1.54				9.3	3.57					8.9	770	21.0		129	1			o
			16	9.8	59	10.3	642		1.58		1.71				10.2	4.12					9.8	770	21.0		129	1	Ci-St	9	c
			16	10.8	88	11.3	654		1.58		1.68										10.8	770	21.6	66	129	2	Cu, Fr-Cu	5	bc
			16	11.8	87	12.4	672		1.53		1.58				12.3	3.26					11.8	770	20.7	62	129	2		2-3	bc
			16	12.8	107	13.5	746		1.90		1.78				13.5	3.86					12.8	769	21.0		129	2		2-3	bc
			16	13.9	94	14.4	707								14.4	3.67					13.9	769	21.0		129	3		1	b
			16	14.9	105	15.4	714		1.63		1.58				15.4	3.87					14.9	769	21.0		129	4	Cu	2	b
			16	15.8	114	16.4	687		1.59		1.61				16.4	3.29					15.8	769	20.7	77	129	4	Cu	1-2	b
			16	16.8	90	17.4	617		1.44		1.62				17.4	3.46					16.8	769	20.4	75	118	4	Cu	4	bc
			16	17.9	120	18.4	646		1.26		1.35				18.4	3.60					17.9	769	20.0		118	4	Cu	9	o
20.6 S	4.3		16	19.1	123	19.8	696		1.48		1.48										19.1	769	20.0		118	5	Cu	10	o
			16	20.2	70	20.8	664		1.36		1.42										20.2	770	20.2	68	118	5		9-10	o
			16	21.3	101	21.8	781		1.24		1.11										21.3	770	20.0		118	5			o
			16	22.5	120	23.1	633		1.31		1.44										22.5	770	20.0		118	5		10	o
			16	23.7	126	24.3	666		1.11		1.16										23.7	770	20.1	72	118	5			o
			17	1.0	86	1.6	863		1.58		1.27										1.0	769	20.0		119	5			o
			17	2.1	100	2.7	581		1.50		1.79										2.1	768	20.0		119	5			o
			17	3.2	92	3.8	593		1.39		1.63										3.2	768	21.0		119	5			o
			17	4.3	81	5.1	622		1.44		1.61										4.3	768	21.8	68	108	5			o
			17	5.7	84	6.3	637		1.48		1.61										5.7	768	21.0		130	5			o
25.4 S	7.2		18	10.2	107	10.4	519	428	1.38	1.11	1.85	1.80	8.6	2.9	13.8	3.60	12.1	0.70	7.0		10.4	762	21.4	82	132	5	St-Cu	9-10	o
			18	10.7	100																10.7	762	21.4	82	133	4	St-Cu	9-10	o
			18	16.7	104																16.7	758	21.2	80	143	4	Cu	1-2	b
22.4 S	7.5		19	10.8	77	10.6	712	607	1.43	1.34	1.44	1.53	7.2	2.4	15.0	3.56	14.4	1.31	5.3		11.0	758	22.2	75	145	4	Fr-Cu	6-7	bc
			19	11.3	92																								
19.8 S	7.8		20	9.8	88	10.0	747	691	1.60	1.45	1.48	1.46	9.1	3.0	12.3	4.03	14.1	†3.10	7.4		10.2	758	22.7	72	134	4	St, St-Cu	10	o
			20	10.6	94																							10	o
			20	16.6	127																16.8	755	22.7	78	134	4	Cu	6-7	bc
16.9 S	8.0		21	10.6	69	10.2	907	840	1.62	1.50	1.24	1.24	7.2	2.4			11.8	†10.37	3.1	1.9	10.6	758	23.2	80	114	4	St	10	odp
			21	16.8	123																16.8	755	22.7	82	114	4	Cu	6	bc
14.1 S	7.5		22	10.2	51	10.2	933	885	1.68	1.56	1.25	1.23	5.5	1.8	12.5	4.20	11.5	2.46	4.0		10.5	760	23.5	84	149	4	St, St-Cu	10	o
			22	10.8	76																							10	om
13.7 S	7.4		22	16.6	109																16.6	756	24.0	77	171	4		10	o
13.6 S	4.9		23	9.9	95	9.9	768	613	1.30	1.15	1.17	1.30	7.8	2.6	12.4	3.89	11.5	0.98	5.5		10.1	759	24.7	72	182	4	Fr-Cu	0-1	bc
			23	10.4	92																								
14.0 S	2.2		24	10.5	115	10.2	790	627	1.49	1.39	1.31	1.54	11.0	3.7	13.0	3.92	11.8	1.75	3.7		10.8	760	25.0	70	170	3	St	9	orq
			24	11.0	99																						St. Fr-Cu	7	bc
14.6 S	359.6		25	9.8	114	9.8	746	568	1.63	1.24	1.52	1.52	10.9	3.6	12.3	3.82	10.9	5.29	5.3		9.7	760	24.2	78	157	3			bc
			25	16.5	151															7.3	16.5	756	23.5	80	146	5	Cu	7-8	bc
15.8 S	356.4		26	9.4	85	9.7	894	871	1.92	1.78	1.34	1.42	10.6	3.5	11.8	3.84	10.3	5.30	3.3		9.8	762	24.5	77	133	4	Cu		bc
			26	16.4	131																16.4	760	24.5	76	133	4	Cu	7-8	bc
St. Helena																													
17.3 S	352.0	Apr	4	9.8	106	10.4	597	513	1.16	0.97	1.35	1.31			13.6	4.64	11.8	0.98	4.6		10.1	763	24.2	80	110	4		10	rop
			4	17.7	109																17.7	762	24.2	75	110	4		10	o
19.4 S	349.5		5	10.6	104	11.1	654	539	1.52	0.99	1.61	1.30	8.7	2.9	13.6	3.51	12.3	0.82	6.1		10.0	764	25.4	68	109	4		10	op
			5	16.5	142																16.5	763	24.3	80	109	4		0	b
21.6 S	347.6		6	9.9	107	10.0	565	621	1.01	1.25	1.24	1.40	8.1	2.7	12.2	3.86	11.3	0.82	5.4		10.2	764	25.5	70	109	1			c
			6	16.8	120																16.8	762	25.6	66	64	3		1	bc
22.7 S	346.7		7	9.7	76	10.0	566	403	0.92	1.06	1.13	1.83	5.0	1.7	11.8	3.79	10.7	0.50	6.9		10.1		26.5	64	64	1		0	b
			7	17.0	98																							0	b
24.3 S	345.7		8	6.9	94	7.5	747		1.58		1.46				7.4	3.78					6.9	761			300	4		2-3	b
			8	8.0	100	8.6	737		1.53		1.44				8.5	3.50					8.0	761	24.8	79	300	4	Ci-Cu	6	bc
			8	9.0	108	9.6	639		1.48		1.61				9.6	3.67					9.0	761			289	4	Ci-Cu	7-8	c
			8	10.1	106	10.8	655		1.63		1.73				10.7	4.30					10.1	761			300	4		8	cr

†Not used in the computation of Q, [illegible].

FINAL RESULTS OF OCEAN ATMOSPHERIC-ELECTRIC OBSERVATIONS ON THE CARNEGIE, 1915–1921—*Continued.*

CRUISE VI, ATLANTIC OCEAN, 1919–1920—*Continued.*

Lat.	Long. E. of Gr.	Date	Potential gradient L.M.T.	Potential gradient P	L.M.T.	Ionic content n_+	Ionic content n_-	Conductivity λ_+	Conductivity λ_-	Ionic mobility k_+	Ionic mobility k_-	Current-density, i	Current-density, i	Penetrating radiation L.M.T.	Penetrating radiation R	Radioactive content L.M.T.	Radioactive content Ionization η_0	Radioactive content Ionization ΔT	Q	Meteorological data L.M.T.	Pressure	Temp. Cent.	Rel. hm.	Wind True dir.	Wind Force	Clouds Kind	Clouds Am't	Weather
°	°	1920	h	$\left(\frac{v}{m}\right)$	h	$\left(\frac{ions}{cc}\right)$		(ESU×10^{-4})		$\left(\frac{cm/s}{v/cm}\right)$		(ESU× 10^{-7})	$\left(\frac{a\times10^{-18}}{cm^2}\right)$	h	$\left(\frac{ions/cc}{s}\right)$	h	$\left(\frac{ions/cc}{s}\right)$	m	*	h	mm	°	p. ct.	°				
24.3 S	345.7	Apr 8	11.4	106	12.0	734		1.48		1.40				11.8	3.68					11.4	761			289	4	Ci-Cu	5	bcq
		8	12.4	107	13.2	836		1.63		1.36				13.1	3.30					12.4	760	25.7	80	266	4	Ci, Cu	6	bc
		8	14.0	113	14.5	797								14.4	3.15					14.0	760			266	4			cpq
		8	15.0	126	15.5	821		1.70		1.44				15.5	3.84					15.0	759			255	4	Cu	6	bcq
		8	16.0	93	16.8	757		1.62		1.49				16.7	3.71					16.0	759	25.3	76	244	3	Cu	8–9	cq
		8	17.3	102	17.8	796		1.57		1.37				17.7	5.23					17.3	760			289	1	Cu	9	crq
		8	18.3	80	19.2	811		1.74		1.49										18.3	760			176	2			c
		8	19.7	99	21.2	754		[1]2.76		2.53										19.7	760	23.5	88	143	3			c
		8	21.8	74	22.4	882		2.71		2.13									0.4	21.8	760			143	2			c
		8	22.9	65	23.5	1050		2.65		1.75										22.9	760				0			bc
		8	24.0	74	24.7	733		1.80		1.70										24.0	760	23.3	86		0			bc
		9	1.2	54	1.7	833		1.93		1.61										1.2	760				0			bc
		9	2.8	66	3.3	761		1.74		1.58										2.8	759				0			bc
		9	3.9	64	4.7	830		1.75		1.46										3.9	758	23.0	88	19	1		3–4	bc
		9	5.4	63																5.4	758				0			cr
26.8 S	344.4	10	12.0	88	11.6	737	643	1.68	1.55	1.58	1.67	9.5	3.2							11.0	759	24.7	73	121	6			bcqp
29.0 S	342.6	11	9.8	102	9.9	669	589	1.30	1.22	1.35	1.44	8.6	2.9	14.0	4.20	11.6	0.47	8.0		10.2	757	24.0	77	76	5			o
		11	16.5	98																16.5	755	23.3	82	87	4		10	o
30.9 S	342.6	12	9.4	79	10.6	673	497	1.24	1.10	1.28	1.54			13.1	3.78	11.4	†0.74	17.0		9.6	753	23.3	88	20	2			bcp
33.4 S	344.1	13	10.4	88	10.4	340	615	1.35	1.63	2.76	1.84	8.7	2.9	13.0	4.32	11.8	0.36	7.3		10.8	749	19.4	74	268	7			bcrt
36.0 S	346.4	14	11.9	187	11.7	761	726	2.19	1.62	1.99	1.54	23.7	7.9							11.0	755	13.7	84	200	3			crq
36.2 S	346.9	14	16.8	134																16.8	762	15.3	68	211	6			bcqr
36.4 S	348.9	15[2]	9.8	112	10.3	664	617	1.57	1.38	1.64	1.55	11.0	3.7	13.6	4.18	11.8	0.33	8.5		10.1	768	16.3	66	7	1			b
36.5 S	349.6	15	16.6	107																16.6	769	17.1	63	356	4		1	b
37.0 S	353.0	16	10.0	119	10.2	723	579	1.38	1.36	1.33	1.63	10.9	3.6	12.9	4.34	11.4	0.59	5.9		10.3	767	16.8	65	332	6			bc
37.2 S	354.1	16	17.8	140																17.8	765	16.5	72	355	5		10	ou
37.4 S	357.7	17	10.6	124	10.4	678	557	1.60	1.01	1.64	1.26	10.8	3.6	14.0	4.27	12.4	†0.20	36.8		10.9	759	17.2	83	354	6		10	ou
37.4 S	358.8	17	16.8	150																16.8	758	17.2	75	343	6		10	ou
37.1 S	2.5	18	12.2	78																12.2	755	15.8	90	184	7		10	o
36.9 S	3.5	18	16.6	112																16.6	760	13.7	82	196	7			o
35.9 S	6.2	19	10.0	67	9.4	571		1.67		2.03										10.0	770	13.4	63	117	4			c
		19	11.0	65	10.6	542		1.72		2.21										11.0	770			106	4	Cu	10	o
		19	11.9	90	11.5	517		1.70		2.29										11.9	770	13.7	61	106	4			c
		19	13.3	85	12.4	551		1.66		2.09										13.3	770			95	4	Cu	6	c
		19	14.5	81	13.9	672		1.57		1.62										14.5	770			118	4		10	o
		19	15.3	88	14.9	646														15.3	770			106	4		10	o
		19	16.3	87	15.9	714		1.91		1.85										16.3	770	13.3	69	95	4		10	o
		19	17.4	96	16.9	739		1.89		1.78										17.4	770			84	4		10	o
36.8 S	6.5	19	19.0	114	17.9	588		1.77		2.09										19.0	771			84	4		10	o
		19	20.1	101	19.6	577		2.05		2.47										20.1	771	14.0	68	72	4			o
		19	21.2	75	20.7	651		2.00		2.13										21.2	771			72	4			o
		19	22.3	87	21.8	544		2.18		2.78										22.3	771			72	4			o

* Curie×10^{-18} per cubic centimeter. † Not used in the computation of Q, lambda. [1] When half way through set, motor began running considerably faster. [2] 50 miles from Tristan da Cunha Islands.

36.8 S	6.5	Apr 19	23.4	80	22.9	671		1.82		1.88										23.4	770			61	4			o
		19	24.4	72	23.9	715		1.67		1.62										24.4	770	14.7	69	61	4			o
		20	1.5	79	1.0	812		1.94		1.66										1.5	769			50	4			o
		20	2.5	63	2.0	786		1.72		1.52										2.5	769			50	4			o
		20	4.7	69	3.1	744		1.80		1.68										4.7	768			50	5			oqr
		20	5.5	66	4.4	626		1.57		1.74										5.5	768			50	5			oq
		20	7.0	71	6.5	728		1.52		1.45										7.0	768			38	5			oq
		20	8.3	84	7.6	709		1.86		1.82										8.3	768	15.0	80	27	5			od
37.5 S	10.5	21	10.6	93	10.5	805	661	1.28	1.06	1.10	1.11	7.3	2.4	13.5	3.60	12.0	0.40	7.5		11.1	765	18.6	80	354	4			bc
37.5 S	11.3	21	16.7	123																16.7	765	17.3	83	5	4			o
36.7 S	12.9	22	9.8	84	9.8	687	485	1.60	1.00	1.62	1.43	7.3	2.4	13.7	3.77	11.1	†1.83	26.0		10.2	764	18.0	87	321	3			ow
35.5 S	15.5	23	9.8	82	10.1	630	639	1.56	1.20	1.72	1.30	7.5	2.5	13.5	3.50	11.4	†9.48	3.4		10.0	763	18.5	90	311	4			o
35.1 S	16.6	23	16.9	105																16.9	763	18.8	85	300	4			o
Cape Town																												
35.5 S	17.9	May 21	10.1	133	10.4	540	440	1.48	1.20	1.90	1.89	11.9	4.0	13.9	3.79					10.4	760	19.7	91	277	4	Cu-Nb	9	cp
38.2 S	18.8	22	11.3	130	9.9	786	614	1.72	1.39	1.56	1.57			13.6	3.76	11.8	0.63	9.4		10.7	759	16.8	71	266	4	Fr, St-Cu	2	bc

CRUISE VI, INDIAN OCEAN, 1920.

°	°	1920	h	(v/m)	h	(ions/cc)		(ESU×10⁻⁴)		(cm/s / v/cm)		(ESU×10⁻⁷)	(α×10⁻¹⁶ cm³)	h	(ions/cc / s)	h	(ions/cc / s)	m	*	h	mm	°	p.d.	°				
30.7 S	25.1	May 24	10.4	102	10.1	994	785	1.77	1.80	1.24	1.59	12.1	4.0	14.6	3.27	13.4	0.68	5.0		10.8	756	12.8	71	222	4	Cu, Fr-Cu	4	bc
39.4 S	29.7	25	16.4	173																14.0	747	17.5	73	335	8		3	oqr
38.6 S	32.0	26			11.3	647	620	2.36	1.58	2.53	1.77									14.2	752	13.6	92	157	6			oqr
36.5 S	34.8	27	11.4	105	11.3	745	792	2.14	1.86	2.00	1.63	14.0	4.7			14.0	0.40	7.5		11.6	762	14.6	70	204	6	Cu, Fr-Cu	4	bcr
36.0 S	35.4	27	17.0	152																17.0	765	14.4	67	204	6	Cu	6	bcr
34.8 S	37.6	28	10.3	111	9.9	768	581	1.25	1.44	1.13	1.72	9.9	3.3	13.3	3.26	11.6	0.19	7.8		10.6	766	17.5	65	239	4	Cu, Fr-Cu	4	bc
33.8 S	40.5	29	11.4	260	11.2	728	552	1.60	1.43	1.52	1.80	25.9	8.6						0.5	11.9	764	18.3	79	274	4	Cu, Cu-Nb	4	bcq
33.6 S	41.5	29	17.1	130																17.1	764	18.4	72	285	4			bcq
33.1 S	44.0	30	10.2	126	9.8	776	574	1.78	1.30	1.59	1.57	12.9	4.3							10.6	764	19.6	61	15	4	Cu, Ci-St	2	bc
33.3 S	45.0	30	16.9	140																16.9	763	19.1	68	26	5			o
34.8 S	47.1	31			11.9	711	627	1.42	1.18	1.39	1.31									11.9	759	16.8	87	37	6			oqrd
34.8 S	47.3	31	15.2	124																15.2	755	16.4	87	82	5			oqr
34.4 S	47.4	Jun 1	10.6	250	10.4	630	395	1.96	0.87	2.16	1.53	23.6	7.9							10.9	753	17.2	79	161	2			oqr
32.7 S	48.4	2	11.2	104	11.3	759	633	1.67	1.67	1.53	1.83	11.6	3.9							11.4	757	17.2	78	128	7	Cu, Fr-Cu	4	bc
32.1 S	49.2	2	[1]16.6	153																16.6	758	16.0	80	175	7			qr
31.4 S	51.9	3	11.0	176	11.2	711	581	1.63	1.44	1.60	1.72	18.0	6.0							11.3	760	16.9	77	196	7	Cu, Fr-Cu	5	bc
30.7 S	56.1	4	11.9	86	11.2	722	645	1.36	1.29	1.31	1.39			14.4	4.36					12.1	759	16.6	74	230	7	Cu, Fr-Cu	5	bcr
30.1 S	60.6	5	11.0	117	10.2	798	724	1.75	1.52	1.52	1.46			13.2	3.71					11.2	759	18.3	88	229	7	Cu-Nb, Fr-Cu		bc
28.1 S	63.4	6	10.4	98	10.2	751	688	1.67	1.82	1.55	1.84	11.4	3.8	13.4	3.84	11.6	[2]2.16	[2]5.3		10.8	760	19.2	84	230	5			bc
27.6 S	64.0	6	16.3	97																16.3	760	19.6	73	230	5		7	c
26.2 S	65.3	7	10.0	88	9.9	718	635	1.50	1.31	1.46	1.43	8.2	2.7	13.6	3.02	11.2	0.77	6.7		10.3	760	20.2	73	253	3			bc
25.6 S	65.6	7	16.5	101																16.5	760	21.2	71	287	4	Ci-Cu	5	bc
23.9 S	66.1	8	6.9	99	7.5	711		2.07		2.03										6.9	758	21.1	82	288	4		2	b
		8	8.1	93	8.6	791		1.92		1.68										8.1	758	21.2	67	300	4		1	b
		8	9.0	106	9.5	777		1.86		1.66										9.0	759			300	4		0-1	b
		8	10.1	109	10.6	784		2.18		1.93										10.1	759			288	4	Ci	8	c
		8	11.0	100	11.7	805		2.19		1.89										11.0	758			288	4	Ci-Cu	7	c
		8	12.1	95	13.1	827		1.97		1.66										12.1	758	22.3	70	266	4		1	b
		8	13.5	100	13.9	776														13.5	757			266	4		1	b
		8	14.4	92	15.1	757		1.57		1.44										14.4	757	23.1	83	255	4		1-2	b
		8	15.5	112	16.1	683		1.59		1.62										15.5	758			255	4	Ci	6	bc
		8	16.6	102	17.1	862		1.98		1.60										16.6	758	22.4	79	255	4	Ci	6	bc
		8	17.6	117	18.1	801		2.05		1.78										17.6	758			266	4			bc
		8	18.6	120	19.3	801		1.95		1.70										18.6	759			266	4			bc
		8	19.8	140	20.4	713		2.07		2.01										19.8	759	21.7	78	266	4			bc
		8	[3]20.9	122																20.9	759			210	4			bc
20.3 S	65.8	9	17.1	116																17.1	759	23.3	68	167	4		3	bc

*Curie×10^{-16} per cubic [illegible]meter.
†Not used in the [illegible] of Q, [illegible].
[1] Set interrupted by rain squall.
[2] These observations give a value of Q=3.4, which was not used in the mean since the shape of the decay-curve indicated a possible land-effect.
[3] Series interrupted here; resumed 24 hours later.

FINAL RESULTS OF OCEAN ATMOSPHERIC-ELECTRIC OBSERVATIONS ON THE CARNEGIE, 1915–1921—*Continued.*

CRUISE VI, INDIAN OCEAN, 1920—*Continued.*

Lat.	Long. E. of Gr.	Date	Potential gradient L. M. T.	Potential gradient P	L. M. T.	Ionic content n_+	Ionic content n_-	Conductivity λ_+	Conductivity λ_-	Ionic mobility k_+	Ionic mobility k_-	Current-density, i	Current-density, i	Penetrating radiation L. M. T.	Penetrating radiation R	Radioactive content L. M. T.	Ionization q_e	Ionization ΔT	Q	Meteorological data L. M. T.	Pressure	Temp. Cent.	Rel. hm.	Wind True dir.	Wind Force	Clouds Kind	Clouds Am't	Weather
°	°	1920	h	$\left(\frac{v}{m}\right)$	h	$\left(\frac{ions}{cc}\right)$		($ESU\times10^{-4}$)		$\left(\frac{cm/s}{v/cm}\right)$		($ESU\times10^{-7}$)	$\left(\frac{a\times10^{-16}}{cm^2}\right)$	h	$\left(\frac{ions/cc}{s}\right)$	h	$\left(\frac{ions/cc}{s}\right)$	m	*	h	mm	°	p. ct.	°				
19.2 S	65.7	Jun 9	22.2	117	21.5	746	...	1.69	...	1.58	...	...	...	...	...	...	...	...	...	22.2	760	...	...	167	4	...	...	bo
		9	23.2	116	22.7	714	...	1.77	...	1.72	...	...	...	...	...	...	...	...	...	23.2	760	...	...	167	4	...	...	o
		9	24.3	139	23.9	742	...	1.71	...	1.60	...	...	...	...	...	...	...	...	...	24.3	760	22.5	64	181	5	...	...	o
		10	1.4	117	0.8	714	...	1.97	...	1.91	...	...	...	...	...	...	...	...	...	1.4	759	...	...	181	5	...	...	o
		10	2.4	94	1.9	799	...	1.91	...	1.66	...	...	...	...	...	...	...	...	...	2.4	759	...	...	147	5	...	...	oo
		10	3.5	92	3.0	811	...	1.78	...	1.52	...	...	...	...	...	...	...	...	...	3.5	759	22.5	65	147	5	...	...	o
		10	4.7	107	4.2	721	...	1.98	...	1.90	...	...	...	...	...	...	...	...	...	4.7	759	...	...	147	5	...	...	o
		10	5.9	116	5.4	755	...	1.77	...	1.62	...	...	...	...	...	...	...	...	...	5.9	759	...	...	158	5	...	...	o
		10	7.2	88	6.5	737	...	1.82	...	1.72	...	...	...	...	...	...	...	...	...	7.2	759	23.4	62	147	5	...	...	o
14.6 S	65.1	11	9.8	102	9.8	770	698	1.78	1.67	1.60	1.65	11.7	3.9	14.6	4.13	...	...	...	...	10.2	762	25.8	65	127	6	Cu	8	o
13.6 S	65.0	11	16.6	92	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	16.6	761	24.7	66	127	6	...	...	bo
10.9 S	64.6	12	10.0	93	9.8	833	692	1.89	1.65	1.58	1.66	11.0	3.7	12.8	3.83	11.3	0.94	6.0		10.3	759	26.2	66	106	6	Cu	0–1	b
10.0 S	64.4	12	16.4	87	...	...	...	...	...	...	...	...	...	...	...	...	...	...		16.4	757	26.0	68	128	5	...	...	...
7.5 S	64.1	13	9.5	100	9.8	692	569	1.38	1.32	1.39	1.61	9.0	3.0	12.6	4.09	11.5	0.65	7.8		9.8	759	26.5	85	130	4	Ci, St-Cu	5	bo
6.9 S	64.0	13	16.6	100	...	...	...	...	...	...	...	...	...	...	...	...	...	...		16.6	756	26.1	77	130	4	...	...	o
5.2 S	63.5	14	9.9	92	11.5	730	619	1.59	1.53	1.51	1.72	...	...	14.8	4.15	13.3	0.71	5.9	0.8	10.3	760	26.5	82	158	4	Ci-Cu	2	b
4.7 S	63.5	14	17.0	75	...	...	...	...	...	...	...	...	...	...	...	...	...	...		17.0	757	27.1	76	153	3	...	...	bo
3.3 S	63.6	15	9.9	87	10.2	683	482	1.52	1.30	1.54	1.87	8.2	2.7	13.7	4.02	11.4	0.46	10.0		10.1	759	27.5	82	154	3	...	...	b
3.0 S	63.5	15	16.5	70	...	...	...	...	...	...	...	...	...	...	...	...	...	...		16.5	757	26.9	76	188	2	Cu	...	bcq
2.2 S	63.2	16	9.6	72	9.7	674	568	1.53	1.22	1.58	1.49	6.6	2.2	12.3	4.22	11.0	0.48	8.4		9.9	760	27.4	68	222	4	...	...	o
1.7 S	63.1	16	16.6	78	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	16.6	757	27.2	74	188	4	...	...	o
0.0	62.9	17	6.6	110	7.3	720	...	1.42	...	1.37	...	...	...	...	...	...	...	...	...	6.6	759	...	...	188	4	Cu	8	o
		17	8.2	76	8.6	643	...	1.40	...	1.51	...	...	...	...	...	...	...	...	...	8.2	760	27.4	72	188	4	...	...	bo
		17	9.1	107	9.6	647	...	1.41	...	1.51	...	...	...	...	...	...	...	...	...	9.1	760	28.0	70	200	4	...	...	bo
		17	10.1	83	10.7	638	...	1.26	...	1.38	...	...	...	...	...	...	...	...	...	10.1	760	...	...	200	4	...	...	bo
		17	11.3	83	11.9	613	...	1.23	...	1.39	...	...	...	...	...	...	...	...	...	11.3	760	...	...	200	4	...	...	bo
		17	12.3	76	13.2	654	...	1.31	...	1.39	...	...	...	...	...	...	...	...	...	12.3	760	28.5	69	200	4	...	...	bo
		17	13.7	85	14.2	683	...	...	...	...	...	...	...	...	...	...	...	...	...	13.7	759	...	...	200	4	Ci	...	bo
		17	14.6	78	15.2	595	...	1.45	...	1.69	...	...	...	...	...	...	...	...	...	14.6	759	...	...	200	4	...	...	bo
		17	15.7	66	16.2	673	...	1.35	...	1.39	...	...	...	...	...	...	...	...	...	15.7	759	28.5	67	200	4	...	...	bo
		17	16.7	88	17.6	548	...	1.44	...	1.83	...	...	...	...	...	...	...	...	...	16.7	759	...	...	200	4	...	...	bo
1.0 N	62.8	17	18.0	88	18.6	583	...	1.63	...	1.94	...	...	...	...	...	...	...	...	...	18.0	759	...	...	211	4	...	...	bo
		17	19.1	92	19.6	593	...	1.30	...	1.52	...	...	...	...	...	...	...	...	...	19.1	760	...	...	211	4	...	...	bo
		17	20.2	119	20.8	631	...	1.32	...	1.45	...	...	...	...	...	...	...	...	...	20.2	760	27.3	72	211	4	...	...	bo
		17	21.2	126	21.8	612	...	1.34	...	1.52	...	...	...	...	...	...	...	...	...	21.2	760	...	...	200	4	...	...	bo
		17	22.2	113	22.7	609	...	1.25	...	1.43	...	...	...	...	...	...	...	...	...	22.2	760	...	...	200	4	...	...	bo
		17	23.2	110	23.8	570	...	1.34	...	1.63	...	...	...	...	...	...	...	...	...	23.2	760	...	...	200	3	...	...	bc
		18	0.2	117	0.9	504	...	1.24	...	1.71	...	...	...	...	...	...	...	...	...	0.2	760	28.0	70	200	4	...	...	bo
		18	1.5	132	2.1	503	...	1.33	...	1.84	...	...	...	...	...	...	...	...	...	1.5	760	...	...	200	4	...	...	bo
		18	2.7	111	3.4	572	...	1.34	...	1.50	...	...	...	...	...	...	...	...	...	2.7	759	...	...	211	4	...	...	bo
		18	3.9	116	4.5	567	...	1.36	...	1.48	...	...	...	...	...	...	...	...	...	3.9	759	27.0	74	211	4	...	...	bo
		18	5.1	106	5.7	597	...	1.30	...	1.70	...	...	...	...	...	...	...	...	...	5.1	759	...	...	200	3	...	...	bo

*Curie×10⁻¹⁶ per cubic centimeter.

1.0 N	62.8	Jun	18	6.1	107	6.7	570		1.48		1.80										6.1	759			200	3			bc
3.7 N	61.8		19	9.9	95	10.0	624	457	1.37	1.21	1.52	1.84	8.2	2.7	13.6	4.08	12.2	0.44	7.6		10.1	760	27.5	72	223	3	Cu, St-Cu	9–10	ocr
4.4 N	61.5		19	16.7	98																16.7	756	27.9	72	234	4			c
6.1 N	60.8		20	9.7	88	9.7	668	551	1.32	1.17	1.37	1.48	7.3	2.4	12.7	4.22	11.4	0.34	10.1		10.0	758	28.4	70	258	4	Cu, Fr-Cu	7	c
6.8 N	60.5		20	16.5	100																16.5	756	28.6	72	246	5		1	c
9.1 N	59.5		21	9.7	108	9.7	612	529	1.20	1.13	1.34	1.48	8.4	2.8	12.5	4.32	11.3	0.52	9.2		10.1	758	28.5	78	236	6			bc
10.0 N	59.3		21	16.5	107															0.4	16.5	754	28.1	78	236	6			bcqd
12.7 N	59.1		22	9.6	136	10.8	398	427	0.96	0.89	1.08	1.45									10.0	756	28.7	77	236	7	Fr-Cu	3	bcs
13.3 N	59.9		22	16.5	163																16.5	752	28.5	77	248	7			bc
12.5 N	62.6		23	10.0	120	10.0	410		1.22	1.01	2.07		8.9	3.0	14.4	4.41	13.5	0.65	7.6		10.4	754	28.7	77	225	7	Fr-Cu	5	bc
12.2 N	63.5		23	16.5	119																16.5	753	29.2	78	225	7			bc
11.2 N	65.8		24	10.0	114	10.2	410	389	1.20	1.25	2.03	2.23	9.3	3.1	13.6	3.91	12.1	0.45	10.9		10.4	756	29.0	76	246	5	Fr-Cu	3	bc
10.7 N	66.7		24	16.6	90																16.6	754	29.4	76	246	5			bc
9.7 N	68.8		25	7.2	133																7.2	756	27.7	83	268	4			bc
			25	10.0	131	11.0	541	516	1.06	1.01	1.36	1.38			15.6	4.18	14.7	†0.81			10.4	756	28.2	84	268	4			bcqr
9.5 N	69.5		25	16.8	106																16.8	755	27.8	80	313	4			oqr
8.7 N	71.5		26	10.0	87	10.9	637	554	1.24	1.27	1.35	1.59			14.7	4.76	12.3	2.46	5.0		10.3	758	27.5	82	245	4		10	o
8.5 N	72.1		26	16.5	91																16.5	755	27.4	85	245	4			od
8.1 N	73.6		27	10.2	[1]293	10.1		228		0.54		1.65									10.9	759	26.2	87	279	1		10	ocr
			27			12.2	664		1.41		1.47																		
8.0 N	74.3		27	16.6	59																16.6	758	27.2	85	279	3		10	or
7.7 N	75.3		28	7.3	110	8.2	607		1.28		1.28										7.3	757	28.0	79	223	3			bc
			28	8.6	106	9.2	770		1.37		1.23										8.6	758	28.0	79	223	3	Ci		bc
			28	9.7	98	10.2	638		1.21		1.32										9.7	758	28.0	79	223	3			bc
			28	10.8	106	11.6	637		1.36		1.48										10.8	758	28.0	79	211	3			bcqr
			28	12.3	86																12.3	757	28.0	79	223	4			bc
7.5 N	78.6		29	10.0	113	10.3	1249	752	1.23	0.89	0.68	0.82	8.0	2.7							10.3	759	25.7	89	257	4			ocr
Colombo																													
4.7 N	80.1	Jul	25	10.2	84	10.4	644	467	0.96	1.08	1.04	1.61	5.7	1.9	13.8	4.38	12.5	1.42	7.5		10.5	757	27.5	85	278	5	A-St	10	or
4.6 N	80.7		25	16.8	60																16.8	755	26.7	88	278	5			o
4.4 N	83.1		26	11.4	78	11.2	668	588	1.25	1.37	1.30	1.62	6.8	2.3	14.0	3.94	12.6	2.91	5.0	3.6	12.0	758	27.5	82	278	4	St-Cu	10	or
4.2 N	84.0		26	16.7	70																16.7	755	27.4	81	244	6		10	o
3.3 N	86.4		27	10.0	88	10.4	595	477	1.26	1.19	1.47	1.73	7.2	2.4	15.0	3.79	11.9	1.30	7.6		10.4	758	28.4	78	245	5	Ci, Cu, A-St		c
3.1 N	87.3		27	16.9	70																16.9	755	29.4	74	222	5	Cu	2	bc
2.2 N	89.7		28	10.0	81	10.0	692	546	1.47	1.15	1.48	1.46	7.1	2.4	13.6	3.82	11.6	0.82	8.7		10.4	758	28.7	84	200	5			co
2.0 N	90.4		28	16.6	88																16.6	756	28.7	79	200	4			o
1.5 N	92.1		29	7.2	76	8.2	755		1.44		1.32										7.2	757			201	3			or
			29	8.8	77	9.7	746		1.30		1.30										8.8	758	28.0	83	178	3			or
			29	10.4	84	11.7		494		1.14		1.87									10.4	758			178	3			oqr
1.6 N	92.5		29	16.5	62										15.9	3.98					16.5	756	27.0	85	167	1		10	or
0.0	94.0		31[2]			10.5	775	667	1.48	1.37	1.32	1.43			14.3	3.45	12.0	2.04	5.2		10.4	757	29.0	79		0			o
1.7 S	94.1	Aug	1[2]			12.5	863	738	2.20	1.62	1.77	1.53					14.6	1.08	5.4		12.0	758	25.8	85	110	3			or
3.4 S	94.3		2[2]			13.6	985	664	1.91	1.72	1.35	1.80			14.6	3.31	11.8	1.24	7.4		10.3	759	30.3	73		0	Ci, Cu	8	c
4.9 S	95.2		3[2]			10.2	781	598	1.91	1.91	1.71	2.22			11.8	3.41	11.5	1.85	6.7		10.8	759	31.1	67		0	Cu	2	b
6.5 S	95.6		4[2]	11.8	56	10.4	887	780	2.00	1.67	1.56	1.49			14.1	3.48	11.2	1.14	5.4		11.2	759	28.2	77	132	1	Cu, St	10	oqp
6.8 S	95.6		4[2]	16.8	58																16.8	756	26.7	82	42	1		9	c
8.0 S	95.6		5[2]			10.1	796	622	1.53	1.40	1.46	1.56			12.3	2.35	10.7	0.41	11.5		9.8	759	30.2	72		0	Ci, Cu	1	b
9.2 S	96.0		6[2]			10.1	778	738	1.34	1.37	1.20	1.29			12.2	3.47	10.8	0.40	10.9		10.0	759	28.3	76		0	Cu	1	b
10.3 S	94.3		7	10.0	120	10.4	732	637	1.20	1.15	1.14	1.25	10.1	3.4	12.5	4.18	11.1	0.54	9.4		10.3	760	27.8	77		0	Ci, Cu	3	bc
10.4 S	94.3		7	17.0	78																17.0	758	28.0	75	131	1			bc
12.0 S	93.1		8	11.4	86	12.1	748	440	1.59	1.51	1.47	2.38			14.2	3.98					11.6	760	26.5	71	108	5			oqr
12.6 S	92.7		8	16.4	81																16.4	758	24.8	88	141	5			oqr
14.5 S	90.8		9	8.2	101	9.0	660		1.13		1.19										8.2	762	25.8	81	128	6			c
			9	9.5	100	10.2	664		1.40		1.46										9.5	763			128	6			c
			9	10.7	109	11.2	552		1.39		1.75										10.7	763			128	6			c
			9	11.9	108	12.5	682		1.43		1.46										11.9	761	26.3	77	128	6			bc

† Not used in the computation of Q, irregular. [1] Potential increased beyond range of electroscope at end. [2] Main engine r...

FINAL RESULTS OF OCEAN ATMOSPHERIC-ELECTRIC OBSERVATIONS ON THE CARNEGIE, 1915–1921—*Continued.*

CRUISE VI, INDIAN OCEAN, 1920—*Continued.*

Lat.	Long. E. of Gr.	Date	Potential gradient L. M. T.	Potential gradient P	L. M. T.	Ionic content n_+	Ionic content n_-	Conductivity λ_+	Conductivity λ_-	Ionic mobility k_+	Ionic mobility k_-	Current-density, i	Current-density, i	Penetrating radiation L. M. T.	Penetrating radiation B	Radioactive content L. M. T.	Ionization q_0	ΔT	Q	L. M. T.	Pressure	Temp. Cent.	Rel. hm.	Wind True dir.	Wind Force	Clouds Kind	Clouds Am't	Weather
°	°	1920	h	(v/m)	h	(ions/cc)		(ESU×10⁻⁴)		(cm/s / v/cm)		(ESU× 10⁻⁷)	(a×10⁻¹⁶ / cm²)	h	(ions/cc / s)	h	(ions/cc / s)	m	*	h	mm	°	p. ct.	°				
14.5 S	90.8	Aug 9	13.3	115	13.9	595														13.3	759			116	6			bc
		9	14.4	102	14.9	702														14.4	758			116	6			bc
		9	15.3	117	16.0	691		1.45		1.46										15.3	759			116	6			bc
		9	16.7	108	17.6	841		1.54		1.27										16.7	759	24.6	79	116	6			bc
16.0 S	89.3	9	18.1	106	19.1	610		1.18		1.34										18.1	760			128	6			bc
		9	19.6	117	20.3	431		1.46		2.35										19.6	761	24.0	84	128	6			bc
		9	21.3	88	22.4	579		1.15		1.38										21.3	761			128	6			o
		9	22.9	114	23.7	659		1.55		1.63										22.9	761			128	6			o
		10	0.3	115	1.1	630		1.34		1.48									0.2	0.3	761	23.5	84	136	6			oq
		10	1.8	126	2.7	645		1.35		1.45										1.8	761			136	6			beq
		10	3.8	133	4.1	665		1.22		1.30										3.3	761	22.5	83	136	6			beq
		10	5.1	127	6.1	676		1.10		1.13										5.1	761			125	6			c
		10	6.7	111	7.3	687		1.28		1.29										6.7	762			125	6			cqr
		10	8.0	92																8.0	762	23.1	83	125	6			cq
19.9 S	85.8	11	10.1	112	10.1	789	711	1.61	1.48	1.41	1.45	11.5	3.8	13.1	3.82	10.6	0.31	11.5		10.4	765	22.5	65	134	5	Cu	5	bc
20.6 S	85.4	11	16.7	117																16.7	762	21.3	69	100	4	Cu	1	b
22.3 S	83.7	12	10.1	102	10.2	866	627	1.57	1.39	1.26	1.54	10.1	3.4	12.2	4.13	10.9	0.77	6.6		10.4	767	21.0	67	132	6	Cu	0–1	b
22.8 S	83.2	12	16.8	108																16.8	767	19.9	72	132	5			bc
24.3 S	81.8	13	10.6	129	10.8	647	553	1.40	1.19	1.50	1.49	11.1	3.7	14.2	3.77	11.5	0.81	9.2		11.0	769	20.7	58	141	5	Cu		bc
24.8 S	81.2	13	17.2	96																17.2	768	18.9	63	141	5	Cu	7	bc
26.1 S	79.5	14	9.0	89																9.0	770	17.3	77	150	4	Fr-Cu, Cu-Nb	8	cr
		14			10.5	1059	804	2.01	1.39	1.31	1.19			14.7	3.73	11.2	†1.71	4.9		10.0	769	17.5	77	139	3			c
		14	11.0	93																11.0	770	18.7	74	139	3	Fr-Cu, Cu-Nb	6	bc
25.7 S	80.2	15	10.8	88	10.3	959	778	1.68	1.52	1.22	1.36	9.4	3.1	14.1	3.71	11.7	0.76	9.9		11.1	770	18.0	60	139	5	Fr-Cu, Cu-Nb	3	bc
26.1 S	79.5	15	16.9	100																16.9	770	17.4	65	150	6			o
27.1 S	78.2	16	9.8	98	9.9	885	815	1.80	1.62	1.42	1.38	11.2	3.7	14.0	3.62	10.7	0.29	10.0		10.1	770	16.7	69	149	4	St-Cu, Fr-Cu	4	bc
27.3 S	77.8	16	17.4	77																17.1	770	16.4	75	149	4			c
28.1 S	76.8	17	10.4	73	10.6	974	818	1.82	1.67	1.30	1.42	8.5	2.8	14.2	3.35	11.4	3.07	7.6		10.7	774	16.8	76	148	4	Cu-Nb, Fr-Cu	5	bcr
28.3 S	76.3	17	16.6	76																16.6	773	16.5	81	148	4			bc
29.3 S	75.0	18	6.8	63	7.5	949		1.99		1.45										6.8	773			147	2			bc
		18	8.1	73	8.6	1041		1.91		1.27										8.1	774	15.4	81	147	3			c
		18	9.0	62	9.5	936		1.88		1.39										9.0	774			147	3			c
		18	10.0	67	10.4	913		1.98		1.51										10.0	774			147	3			cu
		18	10.9	73	11.4	955		1.86		1.35										10.9	774			147	3			c
		18	11.9	74	12.4	951		2.10		1.53										11.9	773	16.5	73	147	3			bc
		18	13.2	70	13.6	956		1.96		1.42										13.2	772			136	3			bc
		18	14.0	74	14.5	904														14.0	772			136	3			bc
		18	14.9	66	15.4	913		2.09		1.53										14.9	772			136	3			bc
		18	15.9	57	16.4	899		1.96		1.52										15.9	772	15.8	75	136	3			c
		18	16.9	63	17.4	894		1.86		1.40										16.9	772			147	4			o
30.2 S	74.1	18	18.9	74	19.5	881		1.88		1.32										18.9	772			147	4			o
		18	19.9	94	20.5	836		1.86		1.56										19.9	773	15.1	74	136	4			c

*Curie×10⁻¹⁶ per cubic centimeter. †Not used in the computation of Q, irregular.

Lat.	Long.	Date		Observed values	Cloud form	Amount
30.3 S	74.1	Aug	[illegible]	[illegible]		
32.3 S	76.7		[illegible]	[illegible]	St, St-Cu	9
32.9 S	76.4		[illegible]	[illegible]		1
33.7 S	79.2		[illegible]	[illegible]	Ci-Cu, St-Cu	2
33.9 S	80.1		[illegible]	[illegible]		
34.0 S	82.2		[illegible]	[illegible]	St, Fr-St	5-9
34.5 S	84.1		[illegible]	[illegible]		
35.1 S	86.9		[illegible]	[illegible]	St-Cu, Fr-Cu	7
35.1 S	87.9		[illegible]	[illegible]		
35.3 S	91.4		[illegible]	[illegible]	St	10
35.7 S	95.4		[illegible]	[illegible]		
35.5 S	99.1		[illegible]	[illegible]	St, Ci, Fr-Cu	4
35.1 S	102.7		[illegible]	[illegible]	St-Cu, Fr-Cu	3
34.9 S	105.6		[illegible]	[illegible]		
34.5 S	105.7		[illegible]	[illegible]		
32.4 S	112.1		[illegible]	[illegible]	Cu	5
32.3 S	113.7		[illegible]	[illegible]		
Fremantle						
36.4 S	116.1	Oct	3	[illegible]	Cu, Fr-Cu	4
37.2 S	117.2		4	[illegible]	Ci	1
39.0 S	117.8		4	[illegible]		
40.7 S	120.7		5	[illegible]		
44.7 S	137.4		8	[illegible]		
45.6 S	150.5		8	[illegible]		2

[1] Not used in the computation of Q, hourly mean.

[2] Rain squall began at end of this set.

FINAL RESULTS OF OCEAN ATMOSPHERIC-ELECTRIC OBSERVATIONS ON THE CARNEGIE, 1915–1921—*Continued.*

Cruise VI, Indian Ocean, 1920—*Concluded.*

Lat.	Long. E. of Gr.	Date	Potential gradient L. M. T.	Potential gradient P	L. M. T.	Ionic content n_+	Ionic content n_-	Conductivity λ_+	Conductivity λ_-	Ionic mobility k_+	Ionic mobility k_-	Current-density, i	Current-density, i	Penetrating radiation L. M. T.	Penetrating radiation R	Radioactive content, Ionization L. M. T.	Ionization q_0	Ionization ΔT	Q	Meteorological data L. M. T.	Pressure	Temp. Cent.	Rel. hm.	Wind True dir.	Wind Force	Clouds Kind	Clouds Am't	Weather
°	°	1920	h	(v/m)	h	(ions/cc)		(ESU×10⁻⁴)		(cm/s / v/cm)		(ESU×10⁻⁷)	(a×10⁻¹⁶/cm²)	h	(ions/cc / s)	h	(ions/cc / s)	m	*	h	mm	°	p.ct.	°				
45.6 S	128.8	Oct 9	3.5	136	2.7	833	.....	1.80	.....	1.50	.....									3.5	757	8.2	95	312	4			o
		9	5.0	132	4.2	770	.....	1.88	.....	1.69	.....									5.0	758	.....	.....	323	4			bo
		9	6.1	136	5.5	720	.....	1.73	.....	1.66	.....									6.1	757	8.9	89	334	4			c
		9	7.3	116	6.8	725	.....	1.82	.....	1.75	.....									7.3	756	9.3	90	334	4			c
		9	8.8	79	8.2	642	.....	1.59	.....	1.72	.....									8.8	756	9.7	92	334	4			o
48.7 S	134.6	10	9.4	70	11.0	734	645	1.53	1.34	1.44	1.44									10.8	743	8.0	95	349	5			o
49.9 S	138.4	11	9.7	100	10.0	806	607	1.57	1.23	1.35	1.41	9.3	3.1							9.4	730	8.0	81	14	5	Ci, St	9	c
		11	12.9	88	12.4	834	.....	1.65	.....	1.37	.....									12.9	728	7.5	87	14	5			c
50.1 S	139.5	11	14.3	101	13.6	701	.....	1.64	.....	1.62	.....									14.3	727	8.8	88	14	5			o
		11	15.2	101	14.7	783	.....	.....	.....	.....	.....									15.2	727	7.7	91	14	5			c
		11	17.7	98	16.1	832	.....	1.61	.....	1.34	.....									17.7	726	7.5	91	14	5			cdm
		11	20.5	74	19.9	749	.....	1.88	.....	1.74	.....									20.5	727	6.1	89	295	5			o
		11	21.7	101	21.1	864	.....	1.55	.....	1.25	.....									21.7	727	6.5	86	295	5		1	bc
50.3 S	141.9	11	23.0	107	22.4	827	.....	1.61	.....	1.35	.....									23.0	728	6.3	80	295	6			bc
		11	24.4	177	23.6	835	.....	1.64	.....	1.37	.....									24.4	729	5.5	79	295	6			cmq
		12	1.5	157	1.0	904	.....	1.78	.....	1.37	.....									1.5	730	5.2	83	289	7			bcqr
		12	2.7	295	2.1	802	.....	1.72	.....	1.50	.....									2.7	731	5.5	79	289	8			bcqr
		12	4.8	264	3.8	884	.....	1.96	.....	1.59	.....									4.8	733	4.4	90	266	8			bcqr
		12	6.4	97	5.7	702	.....	1.67	.....	1.65	.....									6.4	737	4.4	87	266	8			bcq
		12	8.3	113	7.2	810	.....	1.44	.....	1.23	.....									8.3	737	4.4	81	266	8–9			bcqr
		12	.....	.....	9.0	755	.....	1.53	.....	1.40	.....									9.0	737	6.5	89	266	8			bcq

Cruise VI, Pacific Ocean, 1920–1921.

Lat.	Long. E. of Gr.	Date	Potential gradient L. M. T.	Potential gradient P	L. M. T.	Ionic content n_+	Ionic content n_-	Conductivity λ_+	Conductivity λ_-	Ionic mobility k_+	Ionic mobility k_-	Current-density, i	Current-density, i	Penetrating radiation L. M. T.	Penetrating radiation R	Radioactive content, Ionization L. M. T.	Ionization q_0	Ionization ΔT	Q	Meteorological data L. M. T.	Pressure	Temp. Cent.	Rel. hm.	Wind True dir.	Wind Force	Clouds Kind	Clouds Am't	Weather
°	°	1920	h	(v/m)	h	(ions/cc)		(ESU×10⁻⁴)		(cm/s / v/cm)		(ESU×10⁻⁷)	(a×10⁻¹⁶/cm²)	h	(ions/cc / s)	h	(ions/cc / s)	m	*	h	mm	°	p.ct.	°				
48.2 S	155.6	Oct 15	9.9	100	10.4	807	680	1.55	1.45	1.34	1.48	10.0	3.3	14.1	3.71					10.4	743	6.8	61	206	7	Cu, Fr-Cu	7	bcd
47.5 S	159.8	16	11.4	107	11.2	729	695	1.90	1.52	1.81	1.52	12.2	4.1	14.2	4.36					11.7	757	6.8	66	196	6			corq
48.0 S	164.5	17	12.0	81	10.2	819	700	1.88	1.49	1.59	1.48			14.3	3.92	13.0	†0.87	17.1	0.0	12.3	762	10.2	83	265	5		9	op
47.2 S	169.2	18[1]	10.0	95	10.0	889	642	1.61	1.39	1.26	1.50	9.5	3.2	13.5	4.24	11.6	†1.41	6.7		10.3	764	11.0	81	277	6			o
45.5 S	171.4	19[2]	.....	.....	10.2	336	235	0.63	0.50	1.30	1.48			14.0	4.81	12.0	5.25	6.9	7.3	9.8	766	10.8	88	97	1			b
44.6 S	172.8	20[2]	.....	.....	9.9	1150	480	1.07	0.70	0.64	1.01			13.4	4.30	11.8	6.89	5.3		10.2	757	12.2	76	310	2	St-Cu	1	b
Lyttelton																												
44.6 S	175.4	Nov 20	10.0	245	10.7	494	307	0.97	0.79	1.36	1.79			12.2	4.49					10.4	758	11.7	86	40	4	A-St	9–10	o
44.9 S	176.9	21	9.9	255	10.6	330	152	0.59	0.30	1.24	1.37			12.1	7.32					10.2	757	10.5	100	52	2			mfw
46.1 S	177.9	22	8.3	204	9.1	416	.....	1.27	.....	2.12	.....									8.3	739	10.4	99	356	2			c
		22	9.7	171	10.4	791	.....	1.21	.....	1.06	.....									9.7	738	10.5	97	19	2			bc
		22	11.1	192	.....	.....	.....	.....	.....	.....	.....									11.1	737	10.6	95	19	4			f
46.2 S	182.4	22[3]	10.0	94	10.2	623	598	1.42	1.18	1.58	1.37	8.1	2.7	13.0	4.84					10.2	749	9.6	87	289	5		10	or
46.4 S	187.0	23	7.0	249	7.7	306	.....	0.94	.....	2.13	.....									7.0	755	11.0	88	300	6			o

* Curie×10⁻¹⁸ per cubic centimeter. † Not used in the computation of Q, irregular. [1] Near Stewart Island. [2] In sight of land, New Zealand; main engine running. [3] Crossed 180th meridian, hence date November 22 repeated.

48.4 S	187.0	Nov	23	8.5	152	9.1	497		1.07		1.83									8.5	756			300	6		0	b
			23	9.6	153	10.3	537		1.11		1.46									9.6	756	10.9	82	300	6			bc
			23	11.1	144	12.0	836		2.41		1.90									11.1	757	10.5	87	300	6			bc
			23	12.9	117	13.6	638		1.09		1.09									12.9	759	11.0	82	300	6			bc
			23	15.2	123	15.8	605													15.2	760			289	6			bc
			23	16.3	120	17.0	590		1.26		1.51									16.2	762	11.0	82	267	6	Cu	0–1	b
			23	17.5	133	18.2	571		0.90		1.09									17.5	763			267	6			bc
46.4 S	189.1		23	19.2	144	19.9	415		1.20		2.01									19.2	764	9.8	98	267	4			bc
			23	20.4	148	21.5	510		1.16		1.58									20.4	764	9.7	93	267	4			bc
			23	22.1	136	22.7	506		1.33		1.82									22.1	765	9.5	94	267	4			bcw
			23	23.2	170	23.9	508		1.57		2.14									23.2	765	9.4	94	267	3			bcw
			24	0.4	170	1.0	563		1.40		1.73									0.4	765	9.6	94	323				ow
			24	1.5	164	2.1	550		1.18		1.44									1.5	765	9.6	94	334		Ci	8	ocw
			24	2.5	160	3.3	541		1.26		1.62									2.5	765	9.6	94	334				ow
			24	4.0	151	4.7	475		1.33		1.94									4.0	765			334				ow
			24	5.4	110	6.1	521		1.19		1.50									5.4	765	9.7	92	345				o
			24	6.6	129															6.6	765	10.5	92	345				o
46.7 S	194.9		25	9.8	190	10.6	266	193	0.34	0.32	0.89	1.18			13.8	5.52				10.2	762	12.0	98	323	5			fm
46.7 S	199.6		26	10.1	136	10.9	344	242	0.78	0.60	1.58	1.72			12.8	3.97				10.3	759	10.6	100	290	5			omf
45.5 S	207.7		28	9.7	107	10.0	783	579	1.53	1.48	1.40	1.77	10.9	3.6	14.4	3.77				9.9	758	10.8	81	221	3			o
44.2 S	209.8		29	8.2	114	8.9	759		2.10		1.93									8.2	760	11.5	74	153	4	Cu	5	bc
			29	9.4	99	10.0	798		1.84		1.60									9.4	760	11.8	79	176	4	Cu	3	bc
			29	10.4	95	11.0	749													10.4	760	11.5	74	176	4	Cu	1–2	b
			29	15.0	74	15.6	676		1.77		1.82									15.0	761	12.0	78	176	5	Cu	3	bc
			29	16.2	73	16.9	678		1.73		1.77									16.2	761	11.5	83	176	5	Cu	3	bc
			29	17.3	74	17.9	655		1.77		1.88									17.3	762	10.5	87	176	5	Cu	2	b
43.4 S	211.4		29	19.3	87	19.8	577		1.50		1.81									19.3	762	10.1	81	176	5	Cu	2	b
			29	20.2	75	20.9	709		1.37		1.34									20.2	762	10.0	83	176	4	Cu	2	b
			29	21.2	84	21.8	583		1.78		2.12									21.3	763	9.9	88	176	4	Cu	1	b
			29	22.4	71	22.8	558		1.62		2.01									22.4	763	10.0	90	176	3	Cu	1	b
			29	23.3	86	23.9	739		1.60		1.81									23.3	763	10.0	88	176	3	Cu	2	b
			30	0.6	76	1.2	756		1.77		1.62									0.6	763	10.0	88	164	2	Cu	3	bc
			30	1.8	82	2.0	577		1.51		1.82									1.8	763	9.9	88	141	1	Cu	6	bc
			30	2.5	79	3.2	583		1.22		1.61									2.5	763	9.6	74	130	1			bc
			30	4.9	81	5.5	485		1.39		1.98									4.9	764	10.2	74		0			bc
			30	6.1	79	6.9	541		1.12		1.44									6.1	763	11.0	77	18	1			bc
43.4 S	211.7		30	7.4	96	8.0	922		1.72		1.29									7.4	764	11.3	77	18	1			bc
			30	9.5	119	10.0	791		1.60		1.48									9.5	764	11.5	86	355	1		2	b
			30	10.5	[1]110	11.1	780		1.37		1.26									10.5	764	12.4	85	6	2		9	cs
			30	11.6	88	12.2	741		1.38		1.29									11.6	764	12.3	76	6	2			bc
			30	12.7	86	13.2	865		1.46		1.18									12.7	764	12.7	80	18	3			bc
			30	13.8	77															13.8	764	12.0	80	18	3			bc
42.8 S	217.6	Dec	2	9.6	136	10.1	504	353	1.27	0.88	1.75	1.73	9.7	3.2	14.4	4.80				9.9	759	13.2	87	319	4			c
39.7 S	219.3		3	10.0	134	10.2	482	366	1.22	0.96	1.72	1.87	9.7	3.2	14.3	4.34	11.7	0.61	8.4	10.2	756	15.0	81	309	4			bc
37.5 S	222.3		4	9.9	158	10.0	480	249	0.97	0.54	1.50	1.50	7.9	2.6	14.4	4.61				10.2	757	17.0	90	319	4			c
36.3 S	225.5		5	10.4	139	10.6	625	408	1.11	1.02	1.21	1.53	9.2	3.1	15.4	4.67				11.2	755	18.7	89	353	4			cs
34.9 S	226.3		6	11.4	185	11.4	413	307	0.91	0.72	1.53	1.63	9.6	3.0	14.9	3.88				11.6	758	19.3	77	306	6		0	b
33.3 S	227.6		7	9.3	140	10.0	447	297	1.00	0.73	1.55	1.82			14.3	3.94				9.5	762	20.3	66		0			b
32.8 S	227.5		8	9.6	189	9.8	425	315	1.39	0.73	1.86	1.61	11.4	3.8	14.6	3.71	11.4	0.45	8.6	9.8	761	19.0	78	307	2			b
31.8 S	229.3		9	5.7	123	6.3	800		1.29		1.64									5.7	761	20.8	77	284	2		0	b
			9	6.8	119	7.4	539		1.25		1.64									6.8	761	20.9	76	295	2			b
			9	7.8	117	8.4	510		1.25		1.70									7.8	763	21.0	75	284	2	Cu	1	b
			9	8.9	124	9.5	505		1.21		1.66									8.9	763	21.7	74	284	2			bc
			9	10.0	107	10.6	431		1.17		1.69									10.0	763	21.5	72	284	1			bc
			9	11.1	107	11.6	503		1.38		1.77									11.1	762	23.2	67	295	1			bc
			9	12.2	101	13.2	541		1.26		1.61									12.2	762	23.0	69	307	1			bc

[1] Small engine running.

FINAL RESULTS OF OCEAN ATMOSPHERIC-ELECTRIC OBSERVATIONS ON THE CARNEGIE, 1915–1921—*Continued.*

CRUISE VI, PACIFIC OCEAN, 1920–1921—*Continued.*

Lat.	Long. E. of Gr.	Date		Potential gradient L.M.T.	P	L.M.T.	Ionic content n_+	n_-	Conductivity λ_+	λ_-	Ionic mobility k_+	k_-	Current-density, i		Penetrating radiation L.M.T.	R	Radioactive content, Ionization L.M.T.	q_0	ΔT	Q	Meteorological data L.M.T.	Pressure	Temp. Cent.	Rel. hm.	Wind True dir.	Wind Force	Clouds Kind	Clouds Am't	Weather
°	°	*1920*		h	$\left(\frac{v}{m}\right)$	h	$\left(\frac{ions}{cc}\right)$		$(ESU\times10^{-4})$		$\left(\frac{cm/s}{v/cm}\right)$		$(ESU\times10^{-7})$	$\left(\frac{a\times10^{-16}}{cm^2}\right)$	h	$\left(\frac{ions/cc}{s}\right)$	h	$\left(\frac{ions/cc}{s}\right)$	m	*	h	mm	°	p.ct.	°				
31.0 S	228.3	Dec	9	13.6	99	14.1	546	...	...	...	...	...	...	...	...	...	...	...	...		13.6	762	24.3	64	307	1	...	...	bc
			9	14.7	84	15.9	456	...	...	...	...	...	...	...	...	...	...	...	...		14.7	762	23.3	67	307	2	...	...	bc
			9	16.2	63	16.7	534	...	1.42	...	1.85	...	...	...	...	...	...	...	...	0.9	16.2	762	23.1	75	352	2	...	...	bc
			9	17.1	69	17.7	574	...	1.39	...	1.68	...	...	...	...	...	...	...	...		17.1	762	...	...	318	2	Cu	1	b
30.6 S	228.6		9	18.2	70	18.9	575	...	1.48	...	1.79	...	...	...	...	...	...	...	...		18.2	762	21.1	74	340	2	...	...	bc
			9	19.4	57	19.9	631	...	1.34	...	1.47	...	...	...	...	...	...	...	...		19.4	762	21.0	73	340	3	Cu	5	bc
			9	20.3	60	20.8	600	...	1.60	...	1.85	...	...	...	...	...	...	...	...		20.3	763	21.0	76	340	3	...	2	b
			9	21.3	57	22.2	515	...	1.72	...	2.32	...	...	...	...	...	...	...	...		21.3	763	21.0	81	352	3	...	1	b
			9	22.8	68	23.5	481	...	1.34	...	1.93	...	...	...	...	...	...	...	...		22.8	763	21.1	82	352	3	...	0–1	b
			9	24.0	56	24.7	532	...	1.44	...	1.88	...	...	...	...	...	...	...	...		24.0	762	21.0	87	352	4	...	0–1	bcq
			10	1.1	76	...	...	...	...	...	...	...	...	...	...	...	...	...	...		1.1	760	20.8	89	2	4	...	0–1	bw
			10	3.9	102	3.4	560	...	1.40	...	1.74	...	...	...	...	...	...	...	...		3.9	760	20.9	86	340	4	...	...	bc
			10	5.2	117	4.5	557	...	1.15	...	1.43	...	...	...	...	...	...	...	...		5.2	760	...	...	306	5	...	...	bc
30.2 S	227.5		11	9.6	120	10.4	580	354	1.11	0.92	1.33	1.80	...	...	14.5	3.56	12.2	0.49	5.3		9.8	761	22.8	82	261	4	...	...	obcr
29.6 S	226.5		12	9.6	125	9.9	484	395	1.29	1.04	1.85	1.83	9.7	3.2	14.2	3.47	11.3	0.22	8.3		9.9	764	22.2	73	148	4	St, St-Cu	9	o
28.2 S	224.3		13	9.6	150	9.8	727	612	1.48	1.16	1.41	1.32	13.2	4.4	15.2	3.82	11.2	1.10	3.2		9.8	764	24.2	86	92	3	...	...	o
27.5 S	223.1		14	10.0	130	10.8	605	331	1.38	1.03	1.58	2.16	...	...	14.1	3.56	12.0	0.27	9.3		10.2	764	26.7	79	...	0	...	...	bc
26.4 S	221.6		15	9.6	109	9.9	551	346	1.20	1.04	1.51	2.09	8.1	2.7	14.3	3.70	11.5	0.28	5.9		10.0	765	27.2	73	80	4	...	...	bcr
24.3 S	219.5		16	9.6	121	10.6	519	445	1.25	1.05	1.67	1.64	...	...	14.2	3.65	11.7	0.20	8.2		9.9	765	28.2	71	57	4	Cu, Fr-Cu	4	bc
22.4 S	217.2		17	9.5	124	9.9	673	523	1.37	1.15	1.41	1.53	10.4	3.5	14.7	3.67	11.3	0.27	9.6		10.0	762	27.8	70	79	4	Cu, Fr-Cu	3	bc
20.9 S	215.2		18	9.6	125	11.9	[1]615	[1]292	1.28	1.10	[1]1.44	[1]2.62	...	...	...	...	...	...	...	...	9.8	760	28.5	69	34	4	Cu	0–1	b
19.6 S	213.7		19	9.6	108	9.8	410	320	0.95	0.68	1.61	1.48	5.9	2.0	14.1	3.58	...	...	...	...	9.8	758	27.5	79	45	3	...	...	o
18.7 S	212.3		20	9.9	106	10.1	488	339	1.24	0.95	1.76	1.95	7.7	2.6	16.2	3.52	...	...	...	...	10.2	756	28.6	75	337	4	...	...	bc
18.3 S	212.7		21[2]	...	...	10.2	604	351	1.37	0.92	1.57	1.82	...	...	15.0	3.52	...	...	...	...	10.3	756	28.4	77	10	3	...	...	bc
17.8 S	211.5		22[2]	...	...	9.8	560	537	1.20	1.19	1.49	1.54	...	...	...	...	...	...	...	...	10.4	757	28.4	76	...	0	...	...	bcr
Tahiti		*1921*																											
16.5 S	209.5	Jan	4	10.0	101	10.4	458	400	1.70	1.22	2.58	2.12	9.8	3.3	14.9	3.50	...	...	...	...	10.2	759	29.7	67	55	3	...	...	bcq
14.6 S	208.9		5	10.7	95	10.2	501	387	1.32	1.15	1.83	2.06	7.8	2.6	15.0	3.67	...	...	...	...	10.9	758	29.5	74	77	4	...	...	bcq
12.2 S	208.8		6	9.8	87	10.7	560	508	1.62	1.32	2.01	1.80	...	...	14.6	3.62	...	...	...	...	9.1	757	29.7	72	67	4	...	1	bc
10.6 S	208.3		7	9.7	100	9.8	515	428	1.44	1.18	1.94	1.92	8.7	2.9	14.6	3.65	...	...	...	...	9.9	758	29.5	72	88	4	...	...	bc
8.3 S	207.6		8	10.1	88	10.3	593	451	1.42	1.32	1.66	2.03	8.0	2.7	15.2	3.37	...	...	...	...	10.4	757	28.4	71	65	4	Cu, Ci-Cu	7	bc
5.6 S	207.1		9	9.8	108	10.2	499	347	1.52	1.17	2.11	2.34	9.7	3.2	11.9	3.37	...	...	...	...	10.2	757	28.7	71	76	4	Cu, Fr-Cu	1	b
3.6 S	206.0		10	6.5	105	7.3	535	...	1.30	...	1.69	...	...	...	...	...	...	...	...	...	6.5	756	25.7	84	65	3	Ci-Cu	6	bc
			10	7.9	109	9.4	406	...	1.23	...	1.83	...	...	...	...	...	...	...	...	...	7.9	757	26.5	74	65	3	Cu	2	b
			10	9.8	99	10.4	445	...	1.33	...	2.07	...	...	...	...	...	...	...	...	...	9.8	756	27.5	75	53	4	...	...	bc
			10	10.9	92	11.8	457	...	1.08	...	1.64	...	...	...	...	...	...	...	...	...	10.9	756	27.3	74	53	4	...	...	bc
			10	12.2	89	12.8	415	...	1.34	...	2.24	...	...	...	...	...	...	...	...	...	12.2	755	27.7	74	53	4	...	...	bc
			10	13.3	84	13.8	409	...	1.33	...	2.26	...	...	...	...	...	...	...	...	...	13.3	754	27.5	78	53	4	...	...	bc
			10	14.4	74	15.0	476	...	...	...	...	...	...	...	...	...	...	...	...	...	14.4	754	26.2	78	53	4	...	...	bc
			10	15.6	76	16.1	433	...	1.45	...	2.32	...	...	...	...	...	...	...	...	...	15.6	754	26.3	76	65	4	...	...	bc
			10	16.6	82	17.2	466	...	1.84	...	2.00	...	...	...	...	...	...	...	...	...	16.6	754	26.3	75	65	4	Cu	4	bc
			10	17.6	102	18.1	467	...	1.40	...	2.08	...	...	...	...	...	...	...	...	...	17.6	755	25.7	77	65	4	Cu	3	bc

* Curie×10^-18 per cubic centimeter.   [1] Instruments not working properly.   [2] Main engine running.

2.4 S	205.3	Jan	10	18.6	83	19.2	593		1.36		2.41										18.6	755			65	4		1–2	b
			10	19.7	74	20.2	463		1.25		1.87										19.7	756	25.0	81	65	4			bc
			10	20.7	86	21.2	464		1.28		2.08										20.7	756	25.0	81	65	4		0	b
			10	21.7	75	22.3	448		1.31		2.66										21.7	756	25.0	80	65	4			bc
			10	22.8	92	23.3	530		1.44		1.89										22.8	756	24.9	81	53	4		0–1	b
			10	23.8	84	24.3	537		1.24		1.63										23.8	756	24.8	78	53	4		0–1	b
			11	0.7	107	1.1	521		1.32		1.76										0.7	756	24.8	78	53	4		0–1	b
			11	1.6	108	2.5	564		1.44		1.80										1.6	756	24.6	78	53	4			bc
			11	3.1	96	3.7	475		1.30		2.03										3.1	755	24.7	79	53	4			bc
			11	4.4	98	5.2	534		1.18		1.56										4.4	754	24.8	79	53	4			bc
			11	5.7	94	6.3	511		1.44		1.96										5.7	757	24.7	78	53	4		4	bc
			11	6.8	102																6.8	758	26.0	76	53	4	Cu	3	bc
2.0 N	204.3		12	10.0	74	10.3	580	557	1.31	1.22	1.57	1.52	6.2	2.1	12.5	3.62					10.2	758	26.8	76	98	5	Cu	1	b
3.5 N	201.8		13	9.7	106	10.1	440	390	1.08	1.06	1.70	1.89	7.6	2.5	14.7	3.52	12.4	0.57	3.7	0.1	10.0	758	26.2	73	98	4	Cu	9	oq
5.7 N	200.4		15[1]	9.8	80	10.2	584	447	1.45	1.13	1.72	1.75	6.9	2.3	14.6	3.30	10.8	†0.35	11.6		10.0	757	28.5	70	76	4	Cu	3	bc
8.2 N	200.1		16	9.9	75	10.8	664	546	1.45	1.04	1.52	1.32	6.2	2.1	15.0	3.20	12.0	†0.60	5.9		10.1	756	28.2	76	76	4			bc
10.9 N	199.5		17	7.0	82	7.9	736		1.80		1.70										7.0	758	25.7	88	65	4		10	o
			17	8.7	70	9.4	668		1.47		1.53										8.7	758	26.0	88	65	4		10	oq
			17	9.9	82	10.6	630		1.37		1.51										9.9	758	27.2	81	76	4		5	bc
			17	11.4	84	12.1	556		1.26		1.57										11.4	757	27.8	78	65	4			bc
			17	12.6	64	13.4	530		0.93		1.24										12.6	757	27.5	80	76	4	Cu	10	o
			17	14.5	64																14.5	757	25.5	93	76	4			o
16.2 N	197.4		19	9.4	201																10.7	759	24.2	89		0			ouqr
18.9 N	195.4		21	10.3	94	10.6	653	490	1.44	1.21	1.53	1.71	8.3	2.8	13.6	3.38					10.5	759	25.6	83	123	3	Cu, A-Cu	5	bc
21.1 N	194.1		22	7.0	120	8.2	496		1.17		1.04										7.0	760	23.8	90	112	3	Ci-Cu	8	o
			22	8.7	116	9.5	498		1.23		1.72										8.7	761	25.0	84	112	3			bc
			22	10.0	97	10.7	527		1.15		1.52										10.0	761	24.6	87	100	3		10	o
			22	11.3	104	12.0	655		1.49		1.58										11.3	760	25.2	82	100	2		9	or
			22	12.5	78	13.7	793		1.64		1.44										12.5	759	25.3	82	100	2		10	or
			22	14.7	59	15.3	782														14.7	759	24.5	86	123	2		10	o
			22	16.3	57	17.0	711		1.36		1.33										16.3	760	24.0	89	123	2		10	our
			22	17.5	64	18.1	636		1.47		1.63										17.5	760	23.7	91	123	2			ou
21.6 N	193.4		22	18.7	50	19.4	654		1.42		1.51										18.7	760	23.7	89	123	3		10	o
			22	19.9	70	20.4	684		1.86		1.89										19.9	761	23.6	91	123	3		10	o
			22	20.9	57	21.4	742		1.68		1.57										20.9	761	23.6	91	100	3			or
23.2 N	190.7		24	10.1	75	10.4	727	571	1.52	1.33	1.45	1.62	7.1	2.4	14.6	3.50					10.3	762	24.0	81	56	3	Cu, A-Cu	3	b
25.3 N	188.7		25	10.0	101	11.1	763	701	1.48	1.30	1.35	1.29			14.7	3.29					10.2	761	23.5	85	101	4	Cu	10	oq
27.1 N	187.4		26[2]	10.1	103	11.4	591	442	0.97	0.80	1.14	1.26			14.8	3.32					10.3	760	23.4	86	123	3	Ci, Cu	2	bcd
29.1 N	186.5		27[2]	10.7	77	11.6	651	706	1.20	1.53	1.28	1.50			14.2	3.65					10.9	759	20.5	96	258	1	Cu, St-Cu	7	od
31.1 N	186.2		28	11.3	95	10.7	598	607	1.43	1.34	1.06	1.53			15.0	3.82					11.6	759	18.3	69	315	6	Cu	1	b
32.6 N	188.8		29	7.6	100	8.7	901		1.92		1.47										7.6	764	14.7	64	349	4	Cu	3	bc
			29	9.2	106	10.0	975		1.87		1.34										9.2	764	14.8	58	0	2	Cu	2	b
			29	10.5	87	11.1	890		1.65		1.29										10.5	765	14.8	54	12	1			b
			29	11.6	70	12.2	890		1.81		1.41										11.6	765	17.4	50	338	1			bc
			29	12.7	80	13.2	821		1.63		1.38										12.7	764	17.4	49	327	1		2–3	b
			29	13.7	94	14.4	871														13.7	764	17.2	41	327	1			b
			29	14.8	77	15.3	846														14.8	764	18.0	44	327	1	Cu	3	bc
			29	15.8	68	16.7	811		1.43		1.22										15.8	764	15.7	52	327	1			bc
			29	17.2	76	17.7	940		1.63		1.21										17.2	764	15.0	59	259	1	Cu-Nb		u
32.8 N	189.0		29	18.3	76	18.9	1031		2.23		1.51										18.3	765	15.0	55	259	1		7	c
			29	19.4	103	19.9	929		2.05		1.53										19.4	764	15.0	58	259	1		1	b
			29	20.4	120	20.9	1000		1.91		1.33										20.4	764	14.9	51	237	1		0–1	b
			29	21.3	90	21.7	1008		1.96		1.35										21.3	764	15.0	56	237	2	Ci	8	cs
			29	23.8	99	23.4	961		1.91		1.38										23.8	763	15.4	64	237	4		0–1	b
			30	0.9	98	0.4	804		1.91		1.65										0.9	762	15.6	64	214	4		9	c
			30	1.8	98	1.4	843		2.01		1.66										1.8	761	15.8	64	225	5		10	o

†Not used in the computation of Q, irregular.

[1] On January 14 the *Carnegie* stopped for a few hours at Fanning Island.

[2] Four hours of rain preceded observations.

FINAL RESULTS OF OCEAN ATMOSPHERIC-ELECTRIC OBSERVATIONS ON THE CARNEGIE, 1915–1921—*Continued.*

CRUISE VI, PACIFIC OCEAN, 1920–1921—*Continued.*

Lat.	Long. E. of Gr.	Date	Potential gradient L. M. T.	Potential gradient P	L. M. T.	Ionic content n_+	Ionic content n_-	Conductivity λ_+	Conductivity λ_-	Ionic mobility k_+	Ionic mobility k_-	Current-density, i	Current-density, i	Penetrating radiation L. M. T.	Penetrating radiation E	Radioactive content L. M. T.	Radioactive content Ionization η_0	Radioactive content ΔT	Radioactive content Q	Meteorological data L. M. T.	Pressure	Temp. Cent.	Rel. hm.	Wind True dir.	Wind Force	Clouds Kind	Clouds Am't	Weather
°	°	1921	h	(v/m)	h	(ions/cc)		(ESU×10⁻⁴)		(cm/s / v/cm)		(ESU×10⁻⁷)	(a×10⁻¹⁶ / cm²)	h	(ions/cc / s)	h	(ions/cc / s)	m	*	h	mm	°	p. ct.	°				
32.8 N	189.0	Jan 30	2.8	118	2.4	805	.....	1.96	.....	1.69	.....	.....	.....	.....	.....	.....	.....	.....	.....	2.8	760	15.8	68	225	5	.....	3	bc
		30	4.3	110	3.5	712	.....	1.76	.....	1.71	.....	.....	.....	.....	.....	.....	.....	.....	.....	4.3	758	16.0	67	237	5	.....	.....	o
		30	.....	.....	6.3	772	.....	1.60	.....	1.44	.....	.....	.....	.....	.....	.....	.....	.....	.....	6.3	758	15.6	79	237	6	.....	.....	oqr
		31	11.0	112	10.9	689	661	1.38	1.31	1.39	1.38	10.0	3.3	15.2	3.43	.....	.....	.....	.....	11.3	758	13.0	62	305	7	Cu	2	bc
36.3 N	191.3	Feb 1	12.0	77	12.4	547	565	1.17	1.19	1.48	1.46	6.1	2.0	15.3	3.52	.....	.....	.....	.....	12.3	749	13.0	83	272	6	Cu-Nb	10	o
38.3 N	194.2	2	11.5	78	12.4	808	665	1.72	1.39	1.52	1.45	.....	.....	14.5	3.52	.....	.....	.....	.....	11.8	756	12.7	88	216	3	Cu-Nb	9	c
38.6 N	195.5	3	9.4	89	8.8	850	.....	1.88	.....	1.52	.....	.....	.....	.....	.....	.....	.....	.....	.....	9.4	764	12.5	86	172	4	.....	0	b
39.0 N	198.0	3	11.0	88	10.0	823	.....	1.76	.....	1.48	.....	.....	.....	.....	.....	.....	.....	.....	.....	11.0	763	.....	.....	172	4	Ci	1	bs
		3	12.3	90	11.9	786	.....	1.77	.....	1.57	.....	.....	.....	.....	.....	.....	.....	.....	.....	12.3	762	.....	.....	150	4	.....	.....	bc
		3	13.3	83	12.8	749	.....	2.05	.....	1.90	.....	.....	.....	.....	.....	.....	.....	.....	.....	13.3	762	13.0	79	150	4	.....	.....	b
		3	14.4	80	13.8	913	.....	2.13	.....	1.63	.....	.....	.....	.....	.....	.....	.....	.....	.....	14.4	761	12.7	77	150	5	.....	.....	bc
		3	15.6	74	15.0	841	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	15.6	763	12.5	77	150	5	.....	10	o
		3	16.9	88	16.3	777	.....	1.86	.....	1.66	.....	.....	.....	.....	.....	.....	.....	.....	.....	16.9	761	12.0	91	139	5	.....	.....	c
		3	.....	.....	17.7	695	.....	1.83	.....	1.83	.....	.....	.....	.....	.....	.....	.....	.....	.....	17.7	763	12.5	89	139	6	.....	.....	c
39.9 N	211.4	7	11.5	131	12.1	924	660	1.55	1.19	1.17	1.25	.....	.....	.....	.....	.....	.....	.....	.....	11.8	760	12.3	94	187	4	Cu, St-Cu	10	oqr
39.1 N	217.9	9	10.0	155	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	12.2	760	14.5	90	199	6	Cu, Nb	10	o
37.7 N	226.2	13	10.6	118	11.4	.....	687	1.96	1.60	.....	.....	.....	.....	15.2	3.63	.....	.....	.....	.....	10.[illegible]	766	8.3	83	344	7	Cu	6	bcr
37.5 N	226.9	14	11.1	95	11.7	814	777	1.97	1.63	1.68	1.46	.....	.....	.....	.....	.....	.....	.....	.....	11.3	770	9.5	64	345	5	Cu, Ci-Cu	8	cd
38.8 N	230.8	16	11.0	120	11.0	.....	.....	1.86	1.33	.....	.....	12.8	4.3	.....	.....	.....	.....	.....	.....	11.3	757	10.5	94	109	7	Cu, Nb	9	oqr
38.6 N	230.8	17[1]	11.2	240	11.4	730	519	1.18	0.98	1.13	1.31	17.3	5.8	14.3	3.70	.....	.....	.....	.....	11.5	766	12.8	61	289	0–1	Ci	1	bc
38.3 N	233.5	18	8.7	137	9.3	650	.....	0.94	.....	1.00	.....	.....	.....	.....	.....	.....	.....	.....	.....	8.7	768	11.0	82	187	4	.....	10	o
		18	9.9	167	10.6	600	.....	0.97	.....	1.12	.....	.....	.....	.....	.....	.....	.....	.....	.....	9.9	768	11.4	78	187	5	.....	10	o
		18	11.1	161	11.7	613	.....	1.27	.....	1.44	.....	.....	.....	.....	.....	.....	.....	.....	.....	11.1	768	11.6	78	154	5	.....	10	o
		18	12.2	143	12.8	674	.....	1.22	.....	1.26	.....	.....	.....	.....	.....	.....	.....	.....	.....	12.2	768	12.0	74	187	5	Cu	9	c
		18	13.2	137	13.7	640	.....	1.36	.....	1.48	.....	.....	.....	.....	.....	.....	.....	.....	.....	13.2	767	12.1	75	187	5	Cu	9	c
		18	14.4	113	15.1	621	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	14.4	768	11.6	77	187	5	Cu	.....	bc
		18	15.6	100	16.4	660	.....	1.62	.....	1.71	.....	.....	.....	.....	.....	.....	.....	.....	.....	15.6	768	11.6	78	199	5	Cu	2	bc
		18	17.0	109	17.6	609	.....	1.47	.....	1.68	.....	.....	.....	.....	.....	.....	.....	.....	.....	17.0	769	11.0	77	199	5	Cu	9	c
38.0 N	235.	18	18.5	101	19.0	685	.....	1.37	.....	1.39	.....	.....	.....	.....	.....	.....	.....	.....	.....	18.5	769	10.6	81	199	4	.....	2	b
		18	19.5	87	20.0	694	.....	1.40	.....	1.40	.....	.....	.....	.....	.....	.....	.....	.....	.....	19.5	768	10.6	83	199	4	.....	3	bc
		18	20.4	88	21.0	736	.....	1.48	.....	1.40	.....	.....	.....	.....	.....	.....	.....	.....	.....	20.4	769	10.7	82	199	4	.....	6	bc
		18	21.4	86	22.0	714	.....	1.58	.....	1.53	.....	.....	.....	.....	.....	.....	.....	.....	.....	21.4	769	10.7	84	199	4	.....	4	bc
		18	22.5	87	23.0	685	.....	1.48	.....	1.50	.....	.....	.....	.....	.....	.....	.....	.....	.....	22.5	769	10.7	84	199	4	.....	8	c
		18	23.5	93	24.0	698	.....	1.51	.....	1.50	.....	.....	.....	.....	.....	.....	.....	.....	.....	23.5	770	11.5	83	199	4	.....	9–10	o
		19	0.8	92	1.7	635	.....	1.29	.....	1.41	.....	.....	.....	.....	.....	.....	.....	.....	.....	0.8	770	11.0	88	199	3	.....	.....	or
		19	2.2	114	3.2	579	.....	1.43	.....	1.71	.....	.....	.....	.....	.....	.....	.....	.....	.....	2.2	769	11.1	87	199	3	.....	9	cd
		19	3.7	139	4.3	554	.....	1.29	.....	1.62	.....	.....	.....	.....	.....	.....	.....	.....	.....	3.7	769	11.0	90	199	3	.....	5	bc
		19	5.0	136	5.6	586	.....	1.58	.....	1.87	.....	.....	.....	.....	.....	.....	.....	.....	.....	5.0	769	11.3	90	255	3	.....	7	c
		19	6.1	114	6.9	636	.....	[2]1.14	.....	1.24	.....	.....	.....	.....	.....	.....	.....	.....	.....	6.1	769	11.4	90	255	2	.....	.....	o
		19	7.4	172	7.9	637	.....	1.19	.....	1.30	.....	.....	.....	.....	.....	.....	.....	.....	.....	7.4	770	11.2	94	266	2	Cu	.....	bc
San Francisco 36.3 N	235.6	Mar 29	10.1	189	10.4	316	231	0.89	0.78	1.96	2.34	10.5	3.5	14.8	4.03	.....	.....	.....	.....	11.3	759	11.4	87	321	4	.....	10	o

* Curie×10⁻¹⁸ per cubic [illegible]. [1] Main engine running. [2] Occasional puffs of smoke from galley stove.

33.7 N	233.1	Mar	30	9.7	150	10.4	484	387	1.04	0.79	1.49	1.42	...	...	14.4	5.29	...	...	...		9.9	757	13.6	77	320	4	...	9	o
32.0 N	230.9		31	9.8	107	10.8	653	553	1.52	1.12	1.62	1.41	...	...	15.6	3.92	12.9	1.77	6.9		10.1	761	15.1	70	5	3	...	7	o
30.6 N	229.1	Apr	1	11.7	87	10.2	560	428	1.06	0.92	1.32	1.50	...	...	15.2	3.29	11.7	0.90	10.7	1.1	11.9	761	15.6	73	38	3	...	10	o
29.2 N	227.3		2	9.8	73	9.8	846	781	2.03	1.77	1.66	1.58	9.2	3.1	14.4	3.32	11.1	2.17	7.6		10.0	763	16.2	72	15	3	...	9–10	o
27.2 N	225.0		3	9.8	122	10.2	779	724	1.53	1.44	1.37	1.38	12.1	4.0	15.2	3.06	...	...	...		10.3	765	17.5	74	36	5	Cu, St-Cu	8	cp
26.2 N	221.2		4	7.0	93	9.0	768	...	1.62	1.88	1.46	...	...	...	8.8	3.01	...	...	...		7.0	764	17.1	80	58	6	...	7	cpr
			4	9.9	83	11.0	758	...	1.39	1.34	1.28	...	...	...	...	...	...	...	...		9.9	765	17.7	78	58	6	...	10	ou
			4	12.0	109	13.0	...	...	1.59	...	...	...	...	...	...	...	...	...	...		12.0	765	18.7	72	92	6	...	...	o
			4	14.5	92	...	...	...	...	...	...	...	...	...	...	...	...	...	...		14.5	763	18.5	72	58	5	...	...	o
			4	16.2	85	...	...	...	...	...	...	...	...	...	...	...	...	...	...		16.2	762	...	...	70	5	...	...	o
			4	17.7	83	...	...	...	...	...	...	...	...	...	...	...	...	...	...		17.7	762	...	...	70	5	...	...	o
25 8 N	219.6		4	19.2	83	...	...	...	...	...	...	...	...	...	...	...	...	...	...		19.2	763	18.4	74	70	5	...	...	bc
			4	20.8	93	...	...	...	...	...	...	...	...	...	...	...	...	...	...		20.8	763	...	...	92	5	...	...	bcp
			4	22.4	85	...	...	...	...	...	...	...	...	...	...	...	...	...	...		22.4	763	...	...	81	5	...	...	bc
			5	2.4	79	...	...	...	...	...	...	...	...	...	...	...	...	...	...		2.4	761	17.7	85	159	4	...	...	bcuq
			5	4.8	73	...	...	...	...	...	...	...	...	...	...	...	...	...	...		4.8	761	...	...	114	4	Nb	2	bc
			5	6.1	99	...	...	...	...	...	...	...	...	...	...	...	...	...	...		6.1	761	...	...	159	4	...	...	oqr
25.6 N	218.5		5	9.6	94	11.3	...	...	1.09	1.04	...	...	...	...	...	...	...	...	...		9.9	761	20.5	72	114	4	Cu, St-Cu	8	bcq
25.3 N	216.2		6	9.6	133	10.1	595	456	1.47	1.26	1.72	1.92	12.1	4.0	15.0	3.47	...	...	...		9.9	761	23.0	76	125	3	Cu	4	bc
25.2 N	214.9		7[1]	10.0	116	9.9	573	564	1.74	1.43	2.11	1.76	12.3	4.1	14.6	3.05	...	...	...		10.2	761	21.7	73	305	2	St-Cu, Cu-Nb	9	cr
23.8 N	212.1		8	9.6	105	10.2	596	560	1.36	1.30	1.59	1.61	...	...	14.5	3.20	...	...	...		9.8	763	21.0	60	34	4	...	...	bc
23.0 N	209.5		9	8.3	68	9.9	650	...	1.54	1.39	1.65	...			9.6	3.05	...	...	...		8.3	762	21.0	63	57	4	...	10	od
			9	10.8	74	11.9	479	...	1.54	1.66	2.23	...			11.8	2.75	...	...	...		10.8	762	23.0	52	57	4	...	10	o
			9	13.1	78	13.7	737	...	1.65	...	1.56	...			13.7	2.81	...	...	...		13.1	761	23.5	57	57	4	...	...	o
			9	14.2	77	14.8	734	...	...	...	...	...			14.7	3.79	...	...	...		14.2	761	22.7	58	57	4	...	...	bc
			9	15.2	77	15.7	720	...	...	...	...	...			15.5	3.71	...	...	...		15.2	761	22.5	61	57	4	...	...	co
			9	16.1	77	17.2	690	...	1.75	1.66	1.76	...			17.0	2.78	...	...	...		16.1	760	23.7	53	57	4	Cu	...	bc
22.6 N	208.2		9	18.0	73	19.0	...	...	2.04	1.67	...	...			19.3	3.71	...	...	...		18.0	760	21.0	69	57	4	Cu	5	bc
			9	19.7	67	20.5	723	...	1.82	1.45	1.75	...	7.0	2.3	20.4	2.84	...	...	...		19.7	761	20.9	73	57	4	...	...	bc
			9	21.3	52	22.0	730	...	1.85	1.44	1.76	...			21.9	2.49	...	...	...		21.3	762	21.1	65	45	4	...	8	o
			9	22.6	58	23.8	...	...	1.82	1.46	...	...			...	...	...	...	...		22.6	762	21.1	59	45	4	...	9	o
			10	0.6	71	1.2	...	...	1.73	1.44	...	...			1.2	2.64	...	...	...		0.6	761	20.8	63	57	4	...	10	o
			10	1.9	58	2.8	733	...	1.51	1.45	1.42	...			2.6	2.63	...	...	...		1.9	760	20.9	69	57	4	...	10	or
			10	3.5	58	4.6	699	...	1.46	1.49	1.45	...			4.5	3.08	...	...	...		3.5	760	21.0	60	57	4	...	10	o
			10	5.4	65	6.5	628	...	1.62	1.34	1.79	...			6.4	2.78	...	...	...		5.4	760	20.7	66	57	4	...	...	or
			10	7.2	34	8.5	704	...	1.34	1.46	1.33	...			8.4	2.72	...	...	...		7.2	761	...	...	57	3	...	...	or
21.8 N	204.5		11	9.6	78	10.1	783	713	1.35	1.25	1.19	1.21	6.8	2.3	14.3	2.72	...	...	...		9.8	762	23.0	68	78	5	...	...	bcr
Honolulu																													
22.9 N	200.5	Apr	29	9.4	84	10.6	774	1033	1.27	1.20	1.14	0.81	...	...	12.4	3.11	...	...	...		9.7	759	24.3	76	79	4	...	9	o
24.9 N	198.8		30	9.4	87	10.2	804	680	1.73	1.55	1.49	1.58	...	...	12.0	3.08	...	...	...		9.6	759	24.9	66	79	5	...	1	b
27.2 N	198.1	May	1	9.6	90	10.0	678	497	1.67	1.34	1.71	1.87	9.0	3.0	11.7	3.16	...	...	...		9.8	760	23.0	74	124	4	...	10	o
29.5 N	197.4		2	6.4	109	7.9	451	...	1.67	1.10	2.57	...	...	...	7.5	3.29	...	...	...		6.4	761	21.1	85	114	4	...	...	o
			2	9.1	136	10.1	...	...	1.58	1.20	...	...	...	...	10.0	2.84	...	...	...		9.1	760	24.8	76	103	4	...	...	c
			2	11.0	124	11.9	620	...	1.67	1.20	1.87	...	...	...	11.8	3.11	...	...	...		11.1	760	23.2	80	103	4	...	...	c
			2	12.1	99	13.8	700	...	1.64	...	1.62	...	...	...	13.8	2.96	...	...	...		12.1	760	22.5	82	114	4	...	10	o
			2	14.4	94	15.0	727	...	...	...	...	...	...	...	15.0	2.86	...	...	...		14.4	760	21.8	86	114	4	...	10	o
			2	15.4	101	15.9	664	...	...	...	...	...	...	...	16.0	2.99	...	...	...		15.4	760	...	...	125	4	...	10	o
			2	16.4	90	17.3	573	...	1.57	1.22	1.90	...	...	...	17.2	2.84	...	...	...		16.4	760	21.2	88	125	4	...	...	o
			2	18.6	109	19.3	558	...	1.53	...	1.90	...	...	...	19.2	2.65	...	...	...		18.6	760	20.5	90	125	4	...	10	o
			2	20.8	125	...	...	...	...	...	...	...	...	...	...	...	...	...	...		20.8	760	20.1	91	125	4	...	...	odr
34.0 N	200.3		5[1]	10.1	130	10.8	689	457	1.58	1.52	1.59	2.31	...	...	14.5	2.93	...	...	...		12.0	756	17.4	80	...	0	...	...	o
34.1 N	202.3		6	9.8	98	10.0	800	616	1.74	1.42	1.51	1.60	10.3	3.4	11.6	3.01	...	...	...		9.5	756	18.5	72	307	3	...	5	bc
34.2 N	204.1		7	9.9	104	10.4	730	643	1.62	1.66	1.54	1.79	11.4	3.8	13.8	3.22	12.1	2.79	2.7	1.2	10.2	757	18.2	78	285	3	...	...	bc
34.2 N	205.5		8[1]	11.0	149	9.8	886	575	1.81	1.45	1.41	1.75	...	...	13.7	3.08	11.0	2.04	3.1		11.4	758	19.1	73	26	1–2	...	5	bcq
33.7 N	207.3		9	7.2	123	8.2	862	...	1.97	1.46	1.59	...			8.0	3.05	...	...	...		7.2	756	17.0	81	26	3	Cu	7	c
			9	9.0	109	9.9	620	...	1.95	1.38	2.18	...			10.8	2.57	...	...	...		9.0	756	18.6	75	26	3	...	...	bc

[1] Main engine running.

FINAL RESULTS OF OCEAN ATMOSPHERIC-ELECTRIC OBSERVATIONS ON THE CARNEGIE, 1915–1921—*Continued.*

CRUISE VI, PACIFIC OCEAN, 1920–1921—*Continued.*

Lat.	Long. E. of Gr.	Date	Potential gradient L. M. T.	Potential gradient P	Ionic content L. M. T.	Ionic content n_+	Ionic content n_-	Conductivity λ_+	Conductivity λ_-	Ionic mobility k_+	Ionic mobility k_-	Current-density, i	Radioactive content*	Penetrating radiation L. M. T.	Penetrating radiation R	Ionization L. M. T.	Ionization q_0	Ionization ΔT	Q	Met. L. M. T.	Pressure	Temp. Cent.	Rel. hm.	Wind True dir.	Wind Force	Clouds Kind	Clouds Am't	Weather
°	°	1921	h	$\left(\frac{v}{m}\right)$	h	$\left(\frac{ions}{cc}\right)$		$(ESU\times10^{-4})$		$\left(\frac{cm/s}{v/cm}\right)$		$(ESU\times10^{-7})$	$\left(\frac{a\times10^{-16}}{cm^2}\right)$	h	$\left(\frac{ions/cc}{s}\right)$	h	$\left(\frac{ions/cc}{s}\right)$	m	°	h	mm	°	p. ct.	°				
33.7 N	207.3	May 9	10.6	98	11.4	833	.....	2.01	1.44	1.68	.....			11.4	3.22	.....	.....	.....	.....	10.6	756	18.7	72	26	3	.....	.....	bc
		9	12.1	109	12.9	762	.....	2.19	1.61	1.99	.....			12.9	3.29	.....	.....	.....	.....	12.1	756	20.0	62	26	3	.....	.....	bc
		9	13.6	114	14.2	892	.....	.....	.....	.....	.....			14.1	3.16	.....	.....	.....	.....	13.6	756	19.5	75	26	3	.....	.....	bcrq
		9	14.5	119	15.0	815	.....	.....	.....	.....	.....			14.9	3.05	.....	.....	.....	.....	14.5	755	19.0	77	15	4	.....	.....	bcrq
		9	15.3	90	16.2	808	.....	2.00	1.63	1.72	.....			16.3	3.11	.....	.....	.....	.....	15.3	754	.....	.....	26	4	Cu	6	bc
		9	17.0	87	18.2	815	.....	1.97	1.44	1.68	.....	12.4	4.1	17.8	2.93	.....	.....	.....	.....	17.0	755	18.0	75	26	4	Cu	5	bc
33.4 N	208.4	9	19.0	129	19.8	783	.....	1.95	1.50	1.73	.....			19.7	2.81	.....	.....	.....	.....	19.0	755	17.3	81	15	4	Cu	3	bcr
		9	20.5	132	21.7	1002	.....	2.00	1.48	1.39	.....			21.4	2.90	.....	.....	.....	.....	20.5	755	17.0	83	15	4	Cu	1	b
		9	22.5	137	23.2	824	.....	1.91	1.56	1.61	.....			23.2	2.81	.....	.....	.....	.....	22.5	755	17.0	84	38	2	Cu	0–1	br
		10	0.2	[1]108	1.6	778	.....	1.80	1.54	1.61	.....			1.3	2.81	.....	.....	.....	.....	0.2	754	16.5	89	4	4	Cu	6	orqbc
		10	2.8	88	3.8	683	.....	1.94	1.37	1.97	.....			3.6	3.26	.....	.....	.....	.....	2.8	753	17.0	81	253	5	.....	.....	oq
		10	4.9	100	5.7	771	.....	2.00	1.58	1.80	.....			5.6	2.90	.....	.....	.....	.....	4.9	752	.....	.....	4	5	.....	.....	o
		10	6.5	99	7.3	851	.....	1.99	1.62	1.62	.....			7.1	3.35	.....	.....	.....	.....	6.5	752	17.2	77	4	5	.....	.....	bc
34.2 N	212.9	11	9.8	136	10.0	602	576	1.25	1.25	1.44	1.51	11.3	3.8	13.8	3.11	11.3	3.23	2.7	1.2	10.0	753	16.5	73	308	5	.....	10	o
34.3 N	215.8	12	10.2	118	10.5	718	588	1.89	1.50	1.83	1.77	13.3	4.4	14.0	3.20	12.4	5.44	4.5		10.4	755	17.5	82	218	4	.....	7	o
33.8 N	217.1	13	10.0	122	10.0	633	504	1.66	1.27	1.82	1.75	11.9	4.0	13.3	3.14	11.6	1.67	3.9		10.5	761	17.5	70	275	2	.....	10	o
33.0 N	218.7	14	9.8	121	9.9	718	507	1.68	1.20	1.63	1.64	11.6	3.9	12.2	3.14	10.7	1.69	3.2		10.5	766	18.0	71	50	3	.....	.....	o
30.8 N	220.1	15	9.8	113	9.8	641	534	1.70	1.39	1.84	1.81	11.6	3.9	11.9	2.75	11.4	1.30	4.2		10.0	766	20.0	74	71	4	.....	.....	bc
28.5 N	221.6	16	7.3	100	8.5	704	.....	1.82	1.52	1.80	.....			6.7	3.20	.....	.....	.....		7.3	764	18.0	81	59	5	Cu	7	o
		16	9.2	89	10.0	779	.....	1.88	1.57	1.68	.....			8.4	3.01	.....	.....	.....		9.2	764	19.9	67	70	5	.....	.....	o
		16	10.7	101	11.6	728	.....	1.86	1.50	1.77	.....			9.9	3.05	.....	.....	.....		10.7	764	21.3	61	59	4	.....	0	b
		16	12.3	83	13.4	743	.....	1.74	1.39	1.61	.....			11.4	3.14	.....	.....	.....		12.3	764	21.4	61	59	5	.....	.....	bc
		16	14.2	84	14.7	702	.....	.....	.....	.....	.....			13.4	3.05	.....	.....	.....		14.2	764	20.0	68	70	4	.....	10	o
		16	15.1	82	15.6	653	.....	.....	.....	.....	.....			14.6	2.99	.....	.....	.....		15.1	764	19.7	68	70	4	.....	10	o
		16	15.9	75	16.5	553	.....	1.67	1.45	2.10	.....			15.5	3.01	.....	.....	.....		15.9	763	19.3	69	70	4	.....	10	o
		16	17.2	73	18.1	651	.....	1.80	1.44	1.92	.....			16.5	3.05	.....	.....	.....		17.2	763	18.7	72	70	4	.....	10	o
27.4 N	222.1	16	18.8	64	19.6	682	.....	1.58	1.53	1.61	.....	9.0	3.0	18.0	2.84	.....	.....	.....		18.8	764	18.5	78	82	4	.....	10	or
		16	20.4	81	21.1	708	.....	1.67	1.51	1.64	.....			19.5	2.81	.....	.....	.....		20.4	764	18.6	77	82	4	.....	10	o
		16	21.8	83	22.6	757	.....	1.77	1.53	1.62	.....			21.0	2.96	.....	.....	.....		21.8	764	18.6	70	70	4	.....	10	o
		16	23.2	92	24.0	674	.....	1.51	1.40	1.56	.....			22.5	3.05	.....	.....	.....		23.2	764	18.5	71	70	4	.....	10	o
		16	24.8	95	25.6	601	.....	1.30	1.19	1.50	.....			23.9	3.35	.....	.....	.....		24.8	763	18.5	74	70	4	.....	9–10	o
		17	2.3	101	3.2	592	.....	1.32	1.20	1.55	.....			1.4	3.41	.....	.....	.....		2.3	763	17.8	73	81	4	.....	10	o
		17	4.2	95	5.2	668	.....	1.59	1.19	1.65	.....			3.0	3.20	.....	.....	.....		4.2	763	18.0	71	70	4	.....	.....	o
		17	6.1	108	6.9	715	.....	1.71	1.23	1.66	.....			5.1	3.11	.....	.....	.....		6.1	764	18.5	70	70	4	.....	.....	o
		17	7.9	104	.....	.....	.....	.....	.....	.....	.....			.....	.....	.....	.....	.....		7.9	764	.....	.....	81	4	.....	.....	o
24.5 N	223.6	18	9.8	107	10.0	708	582	1.48	1.30	1.45	1.43	9.6	3.2	12.2	2.99	10.6	1.30	4.5		10.1	762	21.0	67	69	5	.....	2	bc
22.1 N	224.6	19	9.8	86	10.0	872	791	1.96	1.67	1.56	1.48	10.4	3.5	12.2	3.08	10.7	1.55	3.7		10.0	758	20.0	72	68	5	.....	10	o
20.2 N	225.7	20	9.7	111	9.9	936	696	2.13	1.84	1.58	1.84	14.7	4.9	12.1	3.32	10.5	1.61	3.9	2.1	10.0	757	22.2	63	68	3	.....	2	bc
18.2 N	226.5	21	9.7	98	9.9	847	635	2.08	1.63	1.66	1.78	11.3	3.8	12.6	2.90	10.5	1.58	4.2		10.0	757	22.2	67	67	4	.....	10	o
16.5 N	225.9	22	9.8	105	9.8	676	491	1.63	1.47	1.68	2.06	10.8	3.6	12.0	3.11	10.5	2.33	2.9		10.1	756	23.5	68	66	3	.....	.....	o
14.5 N	224.6	23	6.5	81	7.4	705	.....	1.89	1.56	1.85	.....			7.2	3.01	.....	.....	.....		6.5	755	.....	.....	32	4	Cu	2	b
		23	8.1	99	9.0	686	.....	1.86	1.70	1.74	.....			8.9	2.96	.....	.....	.....		8.1	755	24.5	75	56	4	.....	.....	b

* Curie$\times10^{-16}$ per cubic centimeter.

[1] Rain before and after this set.

14.5 N	224.6	May	23	9.9	91	10.8	605	.....	1.72	1.44	1.97	......			10.8	3.01	.....	.....	.....		9.9	756	24.5	73	55	4	Cu	1–2	b
			23	11.6	113	12.4	730	.....	1.84	1.57	1.75	......			12.2	3.08	.....	.....	.....		11.6	755	25.0	68	77	4	.....	.....	b
			23	13.3	122	13.8	737	.....	1.60	......	1.51	......			13.8	2.72	.....	.....	.....		13.3	754	25.5	70	77	4	.....	.....	bc
			23	14.2	99	14.8	758	.....	.....	.....	.....	......			14.6	2.75	.....	.....	.....		14.2	754	25.5	70	77	4	.....	.....	b
			23	15.2	96	15.6	741	.....	.....	.....	.....	......			15.6	2.90	.....	.....	.....		15.2	754	25.0	72	77	4	.....	.....	bc
			23	16.0	85	16.8	750	.....	1.77	1.09	1.64	......			16.7	3.32	.....	.....	.....		16.0	754	24.1	78	77	4	.....	.....	b
			23	17.6	76	18.4	738	.....	1.91	1.76	1.80	......	10.7	3.6	18.4	2.93	.....	.....	.....		17.6	754	23.7	76	66	4	Cu	1–2	b
13.8 N	223.7		23	19.1	84	19.8	687	.....	1.96	1.62	1.98	......			19.8	2.72	.....	.....	.....		19.1	754	23.3	78	66	4	Cu	0–1	b
			23	20.5	88	21.2	664	.....	2.13	1.74	2.23	......			21.2	2.75	.....	.....	.....		20.5	754	23.3	78	77	4	Cu	0–1	b
			23	22.0	86	22.7	673	.....	2.11	1.61	2.18	......			22.7	2.84	.....	.....	.....		22.0	755	23.3	80	77	4	.....	0	b
			23	23.4	101	24.1	702	.....	1.63	1.82	1.60	......			24.0	2.78	.....	.....	.....		23.4	755	23.1	82	55	4	.....	0–1	b
			24	0.7	99	1.5	651	.....	1.91	1.82	2.04	......			1.4	2.75	.....	.....	.....		0.7	753	23.1	84	66	4	Cu	1	b
			24	2.1	78	3.0	687	.....	1.91	1.51	1.93	......			2.8	2.90	.....	.....	.....		2.1	753	23.5	81	66	4	Cu	4–2	bc
			24	3.9	85	4.9	647	.....	1.81	1.48	1.94	......			4.7	2.86	.....	.....	.....		3.9	753	24.5	73	66	4	Cu	.....	b
			24	5.8	88	7.1	578	.....	1.82	1.38	2.19	......			6.6	3.29	.....	.....	.....		5.8	753	24.0	79	55	4	.....	10	or
10.6 N	221.1		25	9.8	163	10.4	562	339	1.45	0.96	1.79	1.97	......	......	13.9	3.08	.....	.....	.....		10.2	755	27.2	78	65	5	.....	.....	o
9.2 N	219.4		26	9.6	98	10.2	669	589	1.60	1.55	1.66	1.83	......	......	14.2	2.93	10.9	0.88	4.0		10.0	754	28.0	77	43	4	.....	5	bc
8.0 N	218.1		27	9.4	101	10.4	501	499	1.48	1.27	2.05	1.77	......	......	16.0	2.99	.....	.....	.....	......	9.7	754	27.0	82	121	1	.....	.....	oq
7.0 N	217.5		28[1]	11.1	129	10.4	578	566	1.39	1.83	1.67	2.25	......	......	15.6	2.81	.....	.....	.....	......	9.8	753	29.0	76	233	1	.....	.....	oq
5.8 N	217.2		29	10.1	100	10.2	591	367	1.56	1.10	1.83	2.08	9.7	3.2	14.5	2.72	.....	.....	.....	......	10.3	754	28.2	77	144	3	.....	.....	o
5.2 N	216.4		30[1]	9.5	[2]317	10.1	823	919	2.08	1.92	1.75	1.45	......	......	15.7	2.90	.....	.....	.....	......	10.8	754	26.9	86	166	1	.....	.....	ouq
4.6 N	215.5		31	9.1	120	10.2	470	384	1.70	1.32	2.51	2.39	......	......	14.5	2.93	.....	.....	.....	......	9.5	755	27.8	74	132	2	.....	.....	o
2.7 N	213.0	Jun	2	6.5	122	7.8	476	.....	1.47	1.14	2.15	......			7.4	2.78	.....	.....	.....	......	6.5	752	26.3	83	143	4	Cu	2	bc
			2	8.6	124	9.6	525	.....	1.64	1.22	2.17	......			9.7	3.01	.....	.....	.....	......	8.6	752	28.3	74	143	4	Cu	3	bc
			2	10.5	132	11.3	472	.....	1.40	1.38	2.06	......			11.1	2.24	.....	.....	.....	......	10.5	752	28.0	68	143	4	Cu	3	bc
			2	12.1	120	13.1	489	.....	1.56	1.01	2.22	......			12.9	2.42	.....	.....	.....	......	12.1	752	27.8	68	143	5	.....	.....	b
			2	13.8	120	14.3	486	.....	.....	.....	.....	......			14.2	3.05	.....	.....	.....	......	13.8	751	27.5	80	132	5	.....	.....	bc
			2	14.7	111	15.3	477	.....	.....	.....	.....	......			15.2	2.65	.....	.....	.....	......	14.7	750	26.8	77	132	5	Cu	1–2	b
			2	15.7	102	16.4	490	.....	1.44	1.14	2.08	......			16.5	3.01	.....	.....	.....	......	15.7	750	27.2	74	132	5	.....	.....	bc
			2	17.3	106	18.1	561	.....	1.58	1.16	1.96	......	9.9	3.3	18.2	3.08	.....	.....	.....	......	17.3	750	......	....	132	5	Cu	7	bc
1.6 N	212.2		2	18.9	98	19.7	479	.....	1.66	1.13	2.41	......			19.6	2.93	.....	.....	.....	......	18.9	751	26.1	77	132	5	Cu	0–1	b
			2	20.4	102	21.2	553	.....	1.68	1.17	2.11	......			21.1	2.96	.....	.....	.....	......	20.4	752	26.1	77	132	5	Cu	0–1	b
			2	22.0	105	22.7	523	.....	1.57	1.06	2.08	......			22.7	2.50	.....	.....	.....	......	22.0	752	25.9	79	132	5	.....	0–1	b
			2	23.4	100	24.2	524	.....	1.71	1.15	2.27	......			24.2	2.46	.....	.....	.....	......	23.4	752	25.6	79	132	5	.....	0	b
			3	0.9	115	1.7	537	.....	1.45	1.12	1.88	......			1.6	2.57	.....	.....	.....	......	0.9	751	25.5	80	132	5	.....	0	b
			3	2.4	94	3.3	542	.....	1.39	1.15	1.78	......			3.2	2.50	.....	.....	.....	......	2.4	751	25.5	82	132	5	.....	0	b
			3	4.1	106	5.3	451	.....	1.52	1.08	2.24	......			5.2	2.86	.....	.....	.....	......	4.1	751	25.3	77	132	5	Cu	1	b
			3	6.0	115	7.0	515	.....	1.57	1.21	2.12	......			6.9	2.90	.....	.....	.....	......	6.0	751	25.5	79	132	5	.....	.....	b
0.7 S	210.5		4	9.4	151	10.0	554	432	1.37	1.18	1.72	1.90	......	......	14.5	2.75	10.7	0.24	7.0		9.8	752	27.5	72	31	3	.....	5	bc
			4	.....	.....	.....	.....	.....	.....	.....	.....	.....	......	......	.....	.....	11.6	[3]0.26	8.3		.....	.....	.....	.....	.....	.....	.....	.....	bc
1.7 S	209.6		5	9.9	123	9.9	592	429	1.39	1.19	1.63	1.93	10.5	3.5	12.0	2.93	10.6	0.48	4.5		10.2	751	28.4	67	110	3	.....	.....	bc
2.9 S	208.3		6	9.7	132	10.0	562	443	1.60	1.30	1.98	2.04	12.8	4.3	12.2	2.72	10.6	0.39	8.2		10.0	751	28.5	66	121	4	.....	.....	bc
3.7 S	207.2		7	6.6	124	7.6	626	.....	1.66	1.32	1.84	......			7.5	2.93	.....	.....	.....		6.6	751	27.3	77	76	1	Cu	3	bc
			7	8.4	130	9.3	606	.....	1.63	1.24	1.87	......			9.2	3.11	.....	.....	.....		8.4	752	28.3	73	76	1	.....	.....	bc
			7	10.1	135	11.1	556	.....	1.43	1.07	1.79	......			10.9	2.81	.....	.....	.....		10.1	752	28.7	71	87	2	.....	.....	bc
			7	11.9	146	13.0	583	.....	1.44	1.16	1.71	......			12.7	2.65	.....	.....	.....		11.9	751	28.4	73	42	2	.....	.....	bc
			7	13.9	117	14.8	664	.....	1.36	1.44	1.42	......			14.8	2.81	.....	.....	.....		13.9	750	29.0	70	65	2	.....	.....	bc
			7	15.5	99	16.5	648	.....	1.41	1.25	1.51	......			16.3	2.93	.....	.....	.....		15.5	750	28.5	74	76	2	Cu	2	bc
			7	17.3	96	18.2	610	.....	1.40	1.50	1.59	......			18.4	3.05	.....	.....	.....		17.3	750	27.4	77	76	2	Cu	3	bc
4.2 S	206.6		7	18.9	88	19.7	502	.....	1.39	1.29	1.92	......	9.5	3.2	19.7	2.39	.....	.....	.....	0.4	18.9	750	27.2	80	87	2	.....	.....	bcqur
			7	20.5	102	21.4	526	.....	1.45	1.17	1.92	......			21.5	2.57	.....	.....	.....		20.5	751	27.2	80	87	4	.....	0–1	b
			7	22.2	85	23.3	496	.....	1.50	1.17	2.10	......			23.2	3.35	.....	.....	.....		22.2	752	27.1	81	98	3	.....	0–1	b
			8	1.0	92	1.0	551	.....	1.58	1.12	1.99	......			0.9	2.42	.....	.....	.....		1.0	752	27.0	80	110	4	.....	1–2	bc
			8	1.8	84	2.7	519	.....	1.35	1.03	1.81	......			2.6	2.96	.....	.....	.....		1.8	751	26.9	74	110	4	.....	1–0	b
			8	3.5	104	4.7	546	.....	1.38	1.00	1.76	......			4.3	2.90	.....	.....	.....		3.5	751	26.6	74	110	4	.....	4	bc
			8	5.6	121	6.9	593	.....	1.32	0.89	1.55	......			6.5	3.01	.....	.....	.....		5.6	752	26.8	80	110	4	Cu	2	bc

[1] Main engine running.

[2] Heavy rains before and after observations; 15 minutes before this observation the potential gradient did not exceed 75 v/m for a period of 3 minutes.

[3] Repeated observation, using different foil.

FINAL RESULTS OF OCEAN ATMOSPHERIC-ELECTRIC OBSERVATIONS ON THE CARNEGIE, 1915–1921—*Continued.*

CRUISE VI, PACIFIC OCEAN, 1920–1921—*Continued.*

Lat.	Long. E. of Gr.	Date	Potential gradient L.M.T.	Potential gradient P	Ionic content L.M.T.	Ionic content n_+	Ionic content n_-	Conductivity λ_+	Conductivity λ_-	Ionic mobility k_+	Ionic mobility k_-	Current-density, i	Current-density, i	Penetrating radiation L.M.T.	Penetrating radiation R	Radioactive content, Ionisation L.M.T.	Radioactive content, Ionisation n_0	Radioactive content ΔT	Radioactive content Q	Meteorological data L.M.T.	Pressure	Temp. Cent.	Rel. hm.	Wind True dir.	Wind Force	Clouds Kind	Clouds Am't	Weather
°	°	1921	h	$\left(\frac{v}{m}\right)$	h	$\left(\frac{ions}{cc}\right)$		($ESU\times10^{-4}$)		$\left(\frac{cm/s}{v/cm}\right)$		($ESU\times10^{-7}$)	$\left(\frac{a\times10^{-18}}{cm^2}\right)$	h	$\left(\frac{ions/cc}{s}\right)$	h	$\left(\frac{ions/cc}{s}\right)$	m	*	h	mm	°	p.ct.	°				
6.6 S	204.6	Jun 9	9.5	118	10.1	560	492	1.24	1.30	1.54	1.84	...	...	12.1	3.20	10.7	0.32	9.5		9.8	752	29.0	67	99	3	...	...	bc
7.7 S	203.7	10	9.4	118	10.1	531	499	1.29	1.47	1.68	2.04	...	...	12.2	2.75	11.0	0.75	3.2		9.8	752	28.6	73	54	2	...	...	cq
8.7 S	202.8	11	9.5	175	10.4	630	441	1.15	1.05	1.27	1.65	...	...	12.3	2.96	...	...	...		9.8	753	28.8	86	20	3	...	10	oqr
9.4 S	201.1	13[1]	9.6	138	10.6	233	316	0.44	0.94	1.31	2.07	...	...	...	...	...	...	...		9.8	754	28.2	71	65	2	...	...	bc
10.2 S	200.2	14	9.6	105	10.6	588	341	1.50	1.15	1.77	2.34	...	...	15.3	2.99	11.5	0.20	7.8		9.9	752	29.5	73	122	3	...	...	bc
11.1 S	197.4	16[2]	11.3	53	11.3	573	389	1.18	1.25	1.43	2.23	4.3	1.4	14.6	2.81	...	...	...	...	11.6	751	27.2	75	133	3	...	...	oqdr
11.6 S	195.9	17	8.5	139	9.7	543	...	1.45	1.44	1.85	...			9.5	2.63	...	...	...	...	8.5	751	27.7	82	156	2	...	8	c
		17	10.4	111	11.6	585	...	1.64	1.53	1.95	...			11.3	3.08	...	...	...	...	10.4	751	28.2	81	133	4	...	5	c
		17	12.4	113	13.3	586	...	1.46	1.44	1.73	...			13.3	2.69	...	...	...	...	12.4	750	28.0	75	77	5	Ci, Cu	3	bcr
		17	14.2	96	14.8	679	...	...	...	...	...			14.6	2.86	...	...	...	...	14.2	750	27.4	77	88	5	...	...	bc
		17	15.2	87	15.8	655	...	...	...	...	...			15.6	2.96	...	...	...	...	15.2	749	28.2	74	88	5	Ci	...	bc
		17	16.2	96	17.3	659	...	1.59	1.25	1.68	...			17.2	2.93	...	...	...	...	16.2	750	27.7	76	88	4	Ci	...	bc
12.0 S	195.1	17	18.0	93	18.9	627	...	1.53	1.47	1.69	...			18.8	2.93	...	...	...	...	18.0	750	27.2	78	99	2	Ci	...	bc
		17	19.6	76	20.4	636	...	1.6[illegible]	1.36	1.76	...	9.8	3.3	2.03	2.78	...	...	...	...	19.6	751	27.5	78	111	2	Ci	3	bc
		17	21.1	85	22.0	574	...	1.70	1.44	2.06	...			21.9	2.57	...	...	...	...	21.1	751	27.4	80	111	2	Ci	4	bcr
		17	22.8	90	24.0	600	...	1.70	1.35	1.97	...			23.9	2.93	...	...	...	...	22.8	751	27.3	77	111	2	Ci	3	bc
		18	0.8	72	1.4	620	...	1.78	1.43	1.99	...			1.5	2.90	...	...	...	...	0.8	750	27.0	78	122	2	Ci	0-1	b
		18	2.3	73	3.1	535	...	1.60	1.39	2.08	...			3.1	2.96	...	...	...	...	2.3	750	27.0	78	122	2	Ci	0-1	b
		18	4.0	105	5.1	551	...	1.63	1.34	2.06	...			5.1	3.26	...	...	...	...	4.0	749	26.8	83	122	2	...	...	b
		18	6.0	118	7.0	739	...	1.68	1.37	1.58	...			7.2	3.08	...	...	...	...	6.0	750	27.0	80	156	2	Cu	...	b
		18	7.8	109	...	...	...	...	...	...	...			...	...	...	...	...	...	7.8	751	28.0	78	145	2	...	0-1	b
13.3 S	192.4	19	9.6	113	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	10.0	752	28.7	68	145	3	...	...	bc
Samoa																												
13.3 S	187.6	Jul 26[3]	10.1	124	10.6	754	669	1.38	1.25	1.27	1.30	10.9	3.6	12.3	3.29	...	...	...	...	10.5	751	30.5	71	...	0	...	...	bc
14.3 S	187.0	27[4]	9.7	120	10.5	698	612	1.18	0.99	1.17	1.12	...	...	12.0	3.94	...	...	...	...	9.9	751	26.8	82	224	2	Cu, Ci-Cu	2	bc
15.1 S	188.0	28	10.0	126	10.4	739	466	1.76	1.21	1.66	1.80	12.5	4.2	14.5	3.67	...	...	...	...	10.1	753	27.3	82	134	4	Fr-Cu, Cu	7	bcou
16.8 S	188.0	29	6.7	120	7.5	799	...	1.63	...	1.42	...			7.4	4.07	...	...	...	...	6.7	753	25.7	92	67	3	Ci	...	bc
		29	8.0	121	8.6	...	...	...	0.98	...	...			8.5	4.18	...	...	...	...	8.0	750	26.6	87	67	4	Cu, Ci	...	bc
		29	9.1	151	9.6	744	...	1.35	...	1.26	...			9.6	3.14	...	...	...	...	9.1	756	27.1	86	67	4	...	...	bc
		29	10.0	152	10.6	...	...	...	0.82	...	...			10.6	3.29	...	...	...	...	10.0	754	28.0	82	67	3	...	0	b
		29	11.0	131	11.6	716	...	1.30	...	1.26	...			11.8	3.11	...	...	...	...	11.0	754	28.7	80	67	4	...	0	b
		29	12.1	126	12.6	...	...	...	0.93	...	...			12.7	2.84	...	...	...	...	12.1	753	28.6	80	67	3	...	0	b
		29	13.1	123	13.6	...	...	1.32	...	...	...			13.7	3.22	...	...	...	...	13.1	753	28.0	82	67	2	...	0	b
		29	14.1	108	...	...	...	...	...	...	...			...	...	...	...	...	...	14.1	752	...	...	55	1	...	...	bc
		29	15.2	104	15.9	593	...	...	0.98	...	...			15.8	3.05	...	...	...	...	15.2	752	...	...	55	1	...	0	b
		29	16.4	102	16.9	476	...	1.29	...	1.88	...			16.9	3.35	...	...	...	...	16.4	752	27.0	86	55	1	...	0	b
		29	17.5	98	18.2	...	...	...	0.75	...	...	8.0	2.7	18.1	3.88	...	...	...	...	17.5	753	25.8	92	55	1	...	0	b
17.2 S	188.4	29	18.8	107	19.6	...	...	1.24	...	...	...			19.2	2.42	...	...	...	...	18.8	753	25.6	94	44	2	...	0	bw
		29	20.1	115	20.6	...	...	...	0.74	...	...			20.6	3.50	...	...	...	...	20.1	753	25.5	93	55	3	...	0	bw
		29	21.2	139	21.7	...	...	1.13	...	...	...			...	...	...	...	...	...	21.2	753	25.5	94	...	3	...	0	bw
		29	22.3	136	22.9	...	...	...	0.73	...	...			22.8	1.95	...	...	...	...	22.3	754	25.5	94	...	2	...	0	bw
		29	23.4	138	23.9	...	...	1.06	...	...	...			23.9	3.08	...	...	...	...	23.4	754	25.5	94	...	2	...	0	bw

*Curie×10^-18 per cubic centimeter.

1 The *Carnegie* stopped at Penrhyn Island on June 12; observations of June 13 questionable on account of fumes from operation of main engine.

2 The *Carnegie* stopped at Manihiki Island on June 15.

3 Main engine running; Savaii Island 5 miles distant.

4 Main engine running; rain showers on horizon.

17.2 S	188.4	Jul	30	0.4	154	1.0	...	...	...	0.68	...	...			0.9	3.08	...	...	...	...	0.4	754	25.5	94	...	1	...	...	bow
			30	1.4	117	2.1	...	...	0.84	...	...	...			2.0	2.84	...	...	...	...	1.4	754	25.2	95	...	0	...	...	bow
			30	...	...	4.3	...	...	...	0.59	...	...			...	...	...	...	...	...	4.0	753	25.3	96	...	0	...	...	bowf
			30	...	...	5.6	...	...	0.89	...	...	...			...	...	...	...	...	...	5.0	753	25.5	95	...	0	...	...	bow
			30	...	...	6.3	...	...	...	0.50	...	...			...	...	...	...	...	...	6.0	754	25.8	94	...	0	...	...	bow
18.3 S	188.6		31	9.8	109	10.0	803	578	1.58	1.11	1.36	1.33	9.8	3.3	14.9	3.08	...	...	...	...	9.9	755	27.2	84	112	2	Cu, Ci	1	bs
19.2 S	188.0	Aug	1	9.9	145	10.2	958	655	1.67	1.12	1.21	1.19	13.5	4.5	11.5	3.20	...	...	...	...	9.8	756	26.0	88	101	3	...	...	bc
20.8 S	187.5		2	9.8	126	10.6	782	427	1.60	1.01	1.52	1.64	...	...	12.0	2.86	...	...	...	...	9.7	758	26.9	75	...	0	...	...	b
23.8 S	187.6		4	10.0	142	10.9	648	...	1.05	0.65	1.13	...	...	...	12.3	3.05	...	...	...	...	10.1	757	22.3	94	259	2	...	...	mfs
24.3 S	188.1		5	6.9	107	7.7	...	...	1.54	...	...	...	...	...	7.6	3.14	...	...	...	...	6.0	756	21.8	95	327	2	Ci, Ci-Cu	8	c
			5	8.1	111	8.7	...	...	...	1.02	...	...	...	...	8.7	3.32	...	...	...	...	8.1	757	22.3	94	203	4	...	9–10	coq
			5	10.7	83	11.4	...	...	1.46	...	...	...	...	...	...	...	...	...	...	...	10.7	756	...	...	192	4	...	...	o
			5	11.8	64	12.5	...	...	...	1.25	...	...	...	...	...	...	...	...	...	...	11.8	756	21.8	80	181	3	...	10	o
			5	13.0	80	13.5	...	...	1.44	...	...	...	...	...	13.5	3.26	...	...	...	...	13.0	756	22.3	79	181	3	...	10	cr
			5	14.3	92	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	14.3	756	21.5	85	147	1	...	...	bc
			5	15.2	123	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	15.2	755	23.0	78	215	1	...	...	bc
			5	16.1	92	...	...	...	...	...	...	...	...	...	15.9	3.20	...	...	...	...	16.1	755	...	...	170	1	...	...	bc
27.3 S	188.5		7	11.1	119	11.1	686	448	1.39	1.11	1.41	1.72	9.9	3.3	15.0	3.14	...	...	...	...	11.2	757	20.1	75	249	5	St	10	o
29.1 S	191.0		8	10.7	142	10.9	680	597	1.66	1.21	1.70	1.41	13.6	4.5	15.3	3.58	...	...	...	...	10.7	762	17.5	64	238	4	St	9	c
30.1 S	192.5		9	10.6	118	10.6	786	616	1.72	1.37	1.52	1.54	12.2	4.1	15.4	3.29	...	...	...	...	10.8	761	16.7	73	216	4	St	10	our
29.4 S	194.5		10	14.8	102	13.4	852	764	2.03	1.73	1.65	1.57	...	...	...	...	...	...	...	...	12.0	765	16.4	75	137	5	Cu	5	bc
27.2 S	196.2		11	10.6	121	9.8	859	652	2.00	1.49	1.61	1.59	...	...	11.2	3.65	...	...	...	...	10.7	764	18.0	78	114	5	St	10	o
25.2 S	197.5		12	10.4	143	12.1	749	567	1.77	1.52	1.64	1.85	...	...	14.8	3.43	...	...	...	...	10.5	759	19.0	78	124	4	St, St-Cu	9	c
Rarotonga																													
22.9 S	199.9		16	9.6	101	10.5	816	798	1.64	1.48	1.39	1.29	...	...	12.2	3.47	...	...	...	...	9.8	761	20.2	85	102	4	St, St-Cu	9–10	copr
24.2 S	200.5		17	9.9	119	9.5	...	...	...	1.04	...	...	...	...	9.6	3.94	...	...	...	...	9.9	761	23.4	69	282	3	...	0	b
			17	10.9	94	10.5	672	...	1.40	...	1.45	...	...	...	10.4	2.96	...	...	...	...	10.9	758	23.5	68	293	2	...	0	b
			17	12.0	106	11.6	...	...	...	1.15	...	...	...	...	11.6	3.62	...	...	...	...	12.0	758	22.5	72	293	3	Cu	1	b
			17	13.0	109	12.5	853	...	1.67	...	1.36	...	...	...	12.6	3.73	...	...	...	...	13.0	757	22.5	82	293	3	...	2–8	bc
			17	14.0	95	13.5	...	...	...	1.30	...	...	...	...	13.4	2.78	...	...	...	...	14.0	757	20.7	87	282	3	...	10	oqr
24.6 S	202.8		18	9.8	111	10.1	667	549	1.57	1.38	1.64	1.74	10.9	3.6	11.6	3.37	...	...	...	...	9.9	757	19.5	66	203	5	Fr-Cu, St-Cu	7	c
25.4 S	205.9		19	10.0	102	10.4	739	552	1.64	1.42	1.55	1.79	10.4	3.5	12.1	3.58	...	...	...	...	10.1	758	18.0	68	192	5	Fr-Cu, Ci-Cu	3	bc
26.9 S	208.7		20	10.0	107	10.8	676	600	1.62	1.44	1.66	1.67	...	...	12.5	3.62	...	...	...	...	10.0	756	16.4	70	216	7	...	...	bcqr
28.1 S	211.7		21	10.1	207	10.8	636	570	1.53	1.30	1.67	1.58	...	...	14.8	3.71	...	...	...	...	10.1	756	16.4	61	227	7	Cu	4	bcqr
29.0 S	214.7		22	10.0	126	10.6	716	615	1.65	1.39	1.60	1.57	...	...	15.9	3.50	...	...	...	...	10.0	758	16.5	69	238	6	Cu, St-Cu	5	bcqr
29.0 S	216.6		23	8.0	112	7.6	862	...	1.88	...	1.52	...			7.6	3.47	...	...	...	...	8.0	761	15.6	47	...	2	...	10-	o
			23	9.2	129	8.8	...	...	...	1.49	...	...			8.7	3.35	...	...	...	...	9.2	761	16.4	63	...	2	...	10	o
			23	10.2	125	9.7	854	...	1.91	...	1.55	...			9.7	3.11	...	...	...	...	10.2	761	17.0	57	...	2	...	10	o
			23	11.1	111	10.7	...	...	...	1.53	...	...			10.7	3.22	...	...	...	...	11.1	761	18.3	52	...	0	...	10	o
			23	12.1	97	11.7	638	...	1.09	...	1.19	...			11.8	2.93	...	...	...	...	12.1	761	18.5	47	...	0	Ci	3	bc
			23	13.1	97	12.6	...	...	...	1.63	...	...			12.5	3.43	...	...	...	...	13.1	761	19.3	47	...	0	Ci, Ci-Cu	6	bc
			23	14.2	87	13.7	683	...	1.36	...	1.38	...			13.7	3.32	...	...	...	...	14.2	760	18.5	45	...	0	Ci	2	bc
			23	15.2	86	14.7	...	...	...	1.55	...	...			14.7	3.22	...	...	...	...	15.2	760	...	...	...	0	Ci, Ci-Cu	...	bc
			23	16.2	81	15.7	711	...	1.38	...	1.35	...			15.8	3.47	...	...	...	...	16.2	760	...	...	...	0	Ci, Ci-Cu	6	cr
			23	17.5	74	17.0	...	...	...	1.43	...	...			16.6	3.43	...	...	...	...	17.5	761	15.3	63	...	0	...	...	cr
28.9 S	216.6		23	18.6	78	18.1	617	...	1.42	...	1.60	...			18.0	3.11	...	...	...	...	18.6	761	15.4	63	...	0	...	1	b
			23	19.6	66	19.2	...	...	...	1.36	...	...	8.9	3.0	19.2	3.16	...	...	...	...	19.6	762	15.5	62	...	0	...	0	b
			23	20.7	83	20.2	734	...	1.25	...	1.18	...			20.2	3.11	...	...	...	...	20.7	762	15.4	63	...	0	...	0	b
			23	21.8	83	21.2	...	...	...	1.59	...	...			21.2	3.58	...	...	...	...	21.8	762	15.5	63	...	0	...	0	b
			23	22.7	81	22.3	750	...	1.53	...	1.42	...			22.2	3.50	...	...	...	...	22.7	762	15.2	65	...	0	...	0	b
			23	23.6	88	23.2	...	...	...	1.23	...	...			23.2	3.73	...	...	...	...	23.6	761	15.4	62	...	0	Cu	0–1	b
			24	0.6	100	0.2	706	...	1.25	...	1.23	...			0.1	3.58	...	...	...	...	0.6	761	15.5	62	...	0	Cu	1	b
			24	1.8	85	1.1	...	...	...	1.47	...	...			1.1	3.37	...	...	...	...	1.8	761	15.4	63	...	0	...	...	b
			24	2.7	92	2.3	691	...	1.44	...	1.45	...			2.3	3.82	...	...	...	...	2.7	761	15.2	63	...	0	...	0	b
			24	3.8	85	3.3	...	...	...	1.46	...	...			3.3	3.88	...	...	...	...	3.8	761	15.3	64	...	0	...	0	b
			24	4.9	92	4.3	692	...	1.40	...	1.41	...			4.4	3.77	...	...	...	...	4.9	761	15.3	64	...	0	...	0	b

This value questioned, insulation breaking down due to dampness.

FINAL RESULTS OF OCEAN ATMOSPHERIC-ELECTRIC OBSERVATIONS ON THE CARNEGIE, 1915–1921—*Continued.*

CRUISE VI, PACIFIC OCEAN, 1920–1921—*Continued.*

Lat.	Long. E. of Gr.	Date	Potential gradient L. M. T.	Potential gradient P	Ionic content, conductivity, ionic mobility L. M. T.	Ionic content n_+	Ionic content n_-	Conductivity λ_+	Conductivity λ_-	Ionic mobility k_+	Ionic mobility k_-	Current-density, i	Current-density, i	Penetrating radiation L. M. T.	Penetrating radiation R	Radioactive content, Ionization L. M. T.	Ionization q_0	ΔT	Q	Meteorological data L. M. T.	Pressure	Temp. Cent.	Rel. hm.	Wind True dir.	Wind Force	Clouds Kind	Clouds Am't	Weather
°	°	1921	h	(v/m)	h	(ions/cc)		(ESU×10⁻⁴)		(cm/s / v/cm)		(ESU× 10⁻⁷)	(a×10⁻¹⁶ / cm²)	h	(ions/cc / s)	h	(ions/cc / s)	m	*	h	mm	°	p. ct.	°				
28.9 S	216.6	Aug 24	6.0	97	5.5				1.43					5.5	3.77					6.0	761	15.2	62		0		0	b
		24	7.0	86	6.5	663		1.41		1.48				6.5	3.47					7.0	761	15.9	65		0		0	b
		24	8.0	94	7.5				1.43					7.4	3.41					8.0	760				0		0	b
30.1 S	218.0	25	9.8	100	10.3	670	523	1.48	1.16	1.53	1.54	8.8	2.9	14.1	3.41					9.9	759	18.2	77	36	4	St, St-Cu	10	or
30.6 S	221.4	26	10.5	153	10.9	607	512	1.38	1.16	1.58	1.57	13.0	4.3	15.5	3.47					10.5	754	18.5	82	262	5	Cu, St-Cu	3	bc
29.9 S	224.3	27	10.6	140	10.8	644	563	1.93	1.67	2.08	2.06	16.8	5.6	15.2	3.16					10.7	760	15.0	70	148	6	Cu	5	bc
28.4 S	227.1	28	10.3	133	10.3	880	617	1.95	1.72	1.54	1.94	16.3	5.4	11.7	3.43					10.4	763	15.0	61	137	5	Cu, St-Cu	8	c
27.1 S	228.6	29	10.4	99	10.2	696	758	1.80	1.78	1.80	1.63	11.8	3.9	14.7	3.62					10.5	764	17.6	55	114	3		9	oc
29.0 S	228.4	30	7.1	107	7.6				1.41					7.5	4.03					7.1	764	16.6	63	81	3	St-Cu	9	o
		30	8.0	118	8.6	628		1.63		1.80				8.5	3.08					8.0	765	18.0	58	81	3			bc
		30	9.2	101	9.6				1.42					9.5	3.52					9.2	765	18.4	65	81	3	Ci	2	bc
		30	10.1	120	10.6	636		1.67		1.82				10.5	3.29					10.1	765	18.4	58	81	4	Ci	1	b
		30	11.0	129	11.5				1.17					11.4	3.08					11.0	765	17.9	62	81	4			bc
		30	11.9	124	12.4			1.65						12.3	3.41					11.9	765	18.3	62	70	4	Ci, Ci-Cu	5	bc
		30	12.8	132	13.3				1.31					13.6	3.43					12.8	765	17.6	64	70	4	Ci-St	9	c
		30	13.8	123	14.4	686		1.73		1.75				14.3	2.86					13.8	764	18.0	64	70	4	A-Cu	9	c
		30	14.8	100	15.3				1.46					15.3	3.94					14.8	764	17.5	64	58	4			bc
		30	15.8	101	16.2	742		1.63		1.52				16.2	3.14					15.8	764	17.3	73	58	4			bc
		30	16.7	86	17.1				1.45					17.2	2.99					16.7	764	17.5	72	58	5	Ci, Ci-Cu	4	bc
		30	17.6	90	18.2	691		1.60		1.61				18.2	4.07					17.6	764	16.8	69	58	5	St-Cu	6	bc
29.9 S	229.2	30	18.7	79	19.4				1.50			9.9	3.3	19.4	3.43					18.7	765			70	4		2	bp
		30	19.8	68	20.3	752		1.88		1.74				20.2	2.69					19.8	766	16.9	69	81	4		8	c
		30	20.8	82	21.2				1.63					21.2	3.94					20.8	766	16.7	70	47	4		8	c
		30	21.6	75	22.2	774		1.87		1.68				22.0	4.22					21.6	766	16.8	69	47	4			bcz
		30	22.6	70	23.0				1.49					23.0	4.54					22.6	766			36	4		9	cz
		30	23.4	70	23.9	812		1.91		1.63				0.7	3.22					23.4	765	16.9	68	36	4		10	oz
		31	0.3	82	0.8				1.40					2.8	3.22					0.3	765			37	5		10	o
		31	1.2	88	1.8	777		1.45		1.29				4.0	3.50					1.2	765			37	5		9	c
		31	2.4	94	2.9				1.22					5.2	3.05					2.4	764			37	5			o
		31	3.5	94	4.0	676		1.50		1.54				6.2	3.22					3.5	764			37	5			o
		31	4.5	101	5.3				1.29											4.5	764	15.8	79	37	5		7	o
		31	5.7	112	6.3	588		1.53		1.81										5.7	764			37	5			o
		31	6.8	102																6.8	764	16.2	82	37	5		9	c
32.0 S	235.3	Sep 2	9.8	108	11.2	784	716	1.92	1.81	1.70	1.76			16.0	3.26					9.9	759	14.7	91	195	4		5	bcq
31.7 S	236.5	3	9.8	119	10.2	604	553	1.66	1.47	1.91	1.85	12.4	4.1	14.6	3.32					9.9	762	15.0	70	217	2		10	o
31.8 S	238.3	4	10.5	107	11.8	683	631	1.67	1.47	1.70	1.62			15.8	3.50					10.8	761	17.0	14	330	4	St, St-Cu	10	o
31.7 S	241.1	5	10.5	137	11.1	579	558	1.54	1.32	1.85	1.64			15.0	3.43					10.5	760	17.0	96	285	4		10	ofw
31.5 S	242.6	6[1]	10.5	137	10.4	582	398	1.16	1.08	1.38	1.88	10.2	3.4	14.8	3.26					11.0	763	18.0	73		0		7	c
31.4 S	254.7	10[2]	8.5	118	7.9				1.15					7.8	4.24					8.5	755	16.4	70	264	6	A-Cu	8	c
		10	9.6	117	9.1			1.34						9.2	4.49					9.6	755	16.5	69	264	6		0	b
		10	10.7	138	10.2				1.34					10.0	3.79					10.7	755			264	7			bc
		10	11.7	150	11.3			1.43						11.2	4.01					11.7	755	17.3	64	264	7		0	b

* Curie×10⁻¹⁸ per cubic centimeter.

[1] Main engine running.

[2] Heavy rains September 7, 8, and 9.

31.4 S	254.7	Sep	10	12.9	124	12.4				1.39					12.4	3.22	12.9	755	17.3	64	264	7			bc
			10	13.9	122	13.4			1.33						13.4	3.44	13.9	755			264	7	St-Cu	9	co
			10	15.5	118	14.7				1.17					14.5	3.32	15.5	756	16.4	72	264	7		10	oqru
			10			16.5			1.08						16.3	3.47	16.5	756			242	7		10	our
			10	17.8	123	18.5				1.30					18.6	3.79	17.8	756			242	7			ou
30.7 S	257.6		11	10.2	92	10.8			1.36	1.38					14.9	3.85	10.7	762	15.8	66	219	4	Ci, St-Cu	3	bc
29.7 S	259.2		12	8.8	100	10.0	706	591	1.66	1.51	1.63	1.77			14.0	3.14	9.8	765	17.6	55	174	2		3	bc
28.0 S	259.0		13	9.8	117	10.3	573	479	1.61	1.49	1.95	2.16	12.1	4.0	14.2	3.41	10.2	765	19.4	64	82	5		3	bc
25.3 S	258.4		14	7.2	104	6.7	853		1.58		1.28				6.8	3.67	7.2	765	18.2	86	93	4	St, Ci, A-St	8	o
			14	8.1	88	7.7				1.52					7.6	4.09	8.1	765	19.0	80	93	4		10	o
			14	9.1	109	8.7	810		1.66		1.42				8.6	4.28	9.1	765	20.6	80	93	4	Cu, St-Cu	6	bc
			14	10.1	95	9.6				1.59					9.6	3.82	10.1	765	21.1	75	93	4	Cu	6	bc
			14	11.0	106	10.5	653		1.68		1.79				10.6	4.33	11.0	765	21.5	72	93	5		4	bc
			14	11.8	99	11.4				1.56					11.3	3.77	11.8	765	20.5	77	104	4	A-Cu	8	c
			14	12.7	114	12.3	769		1.73		1.56				12.2	3.37	12.7	765	20.4	80	104	4	Ci, Cu, St-Cu	8	c
			14	13.7	142	13.2				1.23					13.0	3.67	13.7	764	19.5	81	104	5	A-Cu	4	bc
			14	14.7	106	14.2	624		1.41		1.57				14.2	3.47	14.7	763	19.3	74	104	5		3	bc
			14	15.6	87	15.2				1.11					15.1	3.16	15.6	763	19.3	74	104	5		1	b
			14	16.5	87	16.1	700		1.60		1.58				16.1	3.52	16.5	763	19.5	70	104	5		1	b
			14	17.4	86	17.0				1.17			9.7	3.2	16.8	3.73	17.4	763	19.6	72	104	5		1	b
23.7 S	258.3		14	18.3	89	17.9	733		1.63		1.54				17.8	3.94	18.3	764			104	5		1–2	b
			14	19.1	92	18.7				1.53					18.6	4.36	19.1	764	19.1	81	104	5		0–1	b
			14	20.0	100	19.6	564		1.43		1.76				19.6	3.47	20.0	765	19.0	80	104	5		0–1	b
			14	21.0	95	20.5				1.29					20.5	3.29	21.0	764	19.0	82	104	5		0–1	b
			14	22.0	88	21.6	688		1.46		1.47				21.5	3.71	22.0	765	19.1	81	104	5		6	bc
			14	23.1	86	22.5				1.34					22.6	4.33	23.1	764	19.4	77	104	5		8	c
			14	24.0	95	23.6	540		1.57		2.02				23.5	3.11	24.0	764	19.1	80	93	6		2–3	bc
			15	0.9	107	0.5				1.24					0.5	3.41	0.9	763	19.0	80	93	6		3	bc
			15	2.0	69	1.5	569		1.59		1.94				1.3	4.09	2.0	763			93	6	A-Cu	10	o
			15	3.2	101	2.7				1.30					2.6	4.33	3.2	763			104	6			oqr
			15	5.7	96	4.9	748		2.00		1.85				4.9	3.82	5.7	763			115	6			oqr
			15			6.8				1.75							6.8	763							oqr
19.4 S	258.0		16	9.7	125	10.3	767	638	1.53	1.33	1.39	1.45			14.5	3.16	10.0	762	20.6	80	102	6		7	bcqr
16.4 S	257.7		17	10.1	115	10.6	732	509	1.54	1.34	1.47	1.83	11.0	3.7	14.3	3.52	11.5	760	21.5	71	113	5			oqr
13.5 S	257.4		18	9.6	112	10.1	661	498	1.44	1.33	1.51	1.85	10.3	3.4	14.5	3.53	10.0	760	22.2	67	112	5		7	bc
10.2 S	257.6		19	9.6	115	10.6	736	538	1.47	1.34	1.40	1.59			14.2	3.50	10.0	758	22.6	72	90	6			bcq
7.6 S	258.6		20	10.2	102	10.2	752	624	1.34	1.30	1.24	1.45	9.0	3.0	14.0	3.98	10.0	757	23.0	76	112	6		5	bcq
5.3 S	259.9		21	7.1	90	7.7				1.35					7.6	3.94	7.1	755	21.4	76	111	4			ou
			21	8.1	98	8.7	624		1.67		1.86				8.6	4.07	8.1	755	22.3	70	123	5			o
			21	9.2	83	9.7				1.50					9.8	3.50	9.2	755	23.2	71	123	5			o
			21	10.3	134	10.8	707		1.69		1.66				10.7	3.71	10.3	754			123	5			oc
			21	11.2	115	11.8				1.11					11.6	3.32	11.2	754	23.0	72	111	5			o
			21	12.2	126	12.5	700		1.51		1.50				12.5	3.29	12.2	754	23.3	71	111	5			c
			21	13.0	139	13.4				1.19					13.4	3.43	13.0	753	23.6	72	111	4			c
			21	13.9	117	15.3	707		1.54		1.51				15.4	3.52	13.9	753	22.8	74	123	4			cr
			21	15.7	80	16.6				1.26					16.3	3.11	15.7	753	21.7	74	111	5			oru
			21	17.2	112	17.7	592		1.29		1.51						17.2	754	20.8	82	111	5			bcqr
4.1 S	260.6		21	18.3	93	18.8				1.25							18.3	754	20.3	85	123	5		7	bcr
			21	19.5	102	20.0	506		1.48		2.03		9.8	3.3			19.5	755	20.0	88	123	5			bcr
			21	20.5	89	21.0				1.32							20.5	755	20.2	86	123	5		3–1	bcsr
			21	21.5	107	22.1	583		1.49		1.77						21.5	755	20.0	89	123	5		8	csr
			21	22.7	87	23.2				1.30							22.7	755	20.0	90	111	5		9	c
			21	23.6	92	24.2	613		1.47		1.66						23.6	755	20.3	85	111	5		10	cm
			22	0.7	89	1.2				1.35							0.7	755	19.2	90	123	5		9	cr
			22	1.8	96	2.5	706		1.54		1.51						1.8	755			123	5	Cu	5	bc
			22	3.1	90	3.8				1.43							3.1	754	19.9	86	111	5		9	c

FINAL RESULTS OF OCEAN ATMOSPHERIC-ELECTRIC OBSERVATIONS ON THE CARNEGIE, 1915–1921—*Continued.*

CRUISE VI, PACIFIC OCEAN, 1920–1921—*Concluded.*

Lat.	Long. E. of Gr.	Date		Potential gradient L.M.T.	Potential gradient P	L.M.T.	Ionic content n_+	Ionic content n_-	Conductivity λ_+	Conductivity λ_-	Ionic mobility k_+	Ionic mobility k_-	Current-density, i	Current-density, i	Penetrating radiation L.M.T.	Penetrating radiation R	Radioactive content, Ionization L.M.T.	Radioactive content, Ionization η_0	Radioactive content, Ionization ΔT	Radioactive content Q	Meteorological data L.M.T.	Pressure	Temp. Cent.	Rel. hm.	Wind True dir.	Wind Force	Clouds Kind	Clouds Am't	Weather
°	°	1921		h	$\left(\frac{V}{m}\right)$	h	$\left(\frac{ions}{cc}\right)$		$(ESU\times10^{-4})$		$\left(\frac{cm/s}{v/cm}\right)$		$(ESU\times10^{-7})$	$\left(\frac{a\times10^{-16}}{cm^2}\right)$	h	$\left(\frac{ions/cc}{s}\right)$	h	$\left(\frac{ions/cc}{s}\right)$	m	*	h	mm	°	p.ct.	°				
4.1 S	260.6	Sep	22	4.2	90	5.2	.....	.....	1.65	.....	.....	.....			.....	.....	.....	.....	.....	.....	4.2	754	19.5	89	111	4	.....	.....	pr
			22	5.6	131	6.4	.....	.....	.....	1.50	.....	.....			.....	.....	.....	.....	.....	.....	5.6	754	.....	.....	111	4	.....	.....	ur
			22	6.9	92	7.4	.....	.....	1.79	.....	.....	.....			.....	.....	.....	.....	.....	.....	6.9	755	20.5	85	123	4	.....	.....	bc
1.7 S	261.9		23	9.6	126	10.1	456	532	1.40	1.16	2.13	1.51	10.8	3.6	15.4	3.11	.....	.....	.....	.....	9.9	757	21.6	79	122	4	.....	8	c
0.1 S	262.5		24	9.6	92	10.0	774	580	1.85	1.39	1.67	1.66	9.9	3.3	14.4	3.37	.....	.....	.....	.....	9.9	756	21.2	84	156	3	.....	0–1	b
0.8 N	264.2		25	9.4	81	10.2	817	591	1.70	1.41	1.44	1.66	.....	.....	14.2	3.47	.....	.....	.....	.....	9.8	756	22.4	84	167	4	.....	10	or
1.3 N	266.5		26	10.2	45	11.1	616	586	1.60	1.48	1.80	1.75	.....	.....	14.6	4.01	.....	.....	.....	.....	10.5	755	22.3	84	167	5	St	10	oqu
2.0 N	268.2		27	9.6	171	10.4	596	546	1.72	1.63	2.00	2.07	.....	.....	15.0	3.88	.....	.....	.....	.....	9.9	755	23.6	82	178	4	St	10	o
2.4 N	270.4		28	7.4	86	8.0	.....	.....	.....	1.63	.....	.....			7.8	3.88	.....	.....	.....	.....	7.4	754	.....	.....	178	4	St, St-Cu	10	o
			28	8.4	60	9.0	720	.....	1.72	.....	1.65	.....			9.0	3.52	.....	.....	.....	.....	8.4	754	22.5	80	167	4	.....	10	o
			28	9.5	56	10.1	.....	.....	.....	1.61	.....	.....			10.0	3.58	.....	.....	.....	.....	9.5	754	22.3	80	178	4	.....	10	o
			28	10.6	54	11.2	591	.....	1.65	.....	1.94	.....			11.0	4.01	.....	.....	.....	.....	10.6	754	.....	.....	178	4	.....	10	o
			28	11.6	23	12.2	.....	.....	.....	1.35	.....	.....			12.2	3.52	.....	.....	.....	.....	11.6	754	21.7	90	178	4	.....	10	od
			28	12.7	38	13.3	642	.....	1.52	.....	1.65	.....			13.0	4.01	.....	.....	.....	.....	12.7	754	23.1	81	178	4	.....	10	o
			28	13.8	42	14.3	.....	.....	.....	1.53	.....	.....			14.3	4.49	.....	.....	.....	.....	13.8	753	23.0	79	178	4	.....	10	o
			28	14.8	71	15.3	698	.....	1.73	.....	1.71	.....			15.2	3.43	.....	.....	.....	.....	14.8	753	22.5	81	178	4	.....	10	o
			28	15.7	56	16.2	.....	.....	.....	1.51	.....	.....			16.2	4.03	.....	.....	.....	.....	15.7	753	22.5	84	178	4	.....	10	o
			28	16.6	54	17.2	927	.....	1.81	.....	1.36	.....			17.0	3.77	.....	.....	.....	.....	16.6	753	22.5	83	178	4	.....	10	o
			28	17.6	43	18.2	.....	.....	.....	1.76	.....	.....			18.2	4.18	.....	.....	.....	.....	17.6	753	22.5	76	167	3	.....	10	o
2.4 N	271.5		28	18.7	132	19.3	769	.....	1.78	.....	1.60	.....			19.2	3.22	.....	.....	.....	.....	18.7	753	22.0	83	167	3	.....	10	odr
			28	19.7	143	20.2	.....	.....	.....	1.68	.....	.....	5.8	2.0	20.2	3.41	.....	.....	.....	.....	19.7	754	22.5	80	167	3	.....	10	or
			28	20.8	43	21.3	647	.....	1.60	.....	1.72	.....			21.2	2.72	.....	.....	.....	.....	20.8	754	22.7	80	167	3	.....	10	o
			28	21.7	55	22.2	.....	.....	.....	1.54	.....	.....			22.1	3.32	.....	.....	.....	.....	21.7	755	22.5	81	167	3	.....	10	o
			28	22.6	20	23.1	755	.....	1.87	.....	1.72	.....			23.1	3.41	.....	.....	.....	.....	22.6	755	22.5	80	167	3	.....	10	or
			28	23.6	45	24.0	.....	.....	.....	1.50	.....	.....			24.0	2.46	.....	.....	.....	.....	23.6	754	22.7	80	167	3	.....	10	o
			29	0.5	60	1.1	847	.....	1.75	.....	1.43	.....			1.0	2.84	.....	.....	.....	.....	0.5	754	22.5	76	167	2	.....	10	o
			29	1.6	67	2.0	.....	.....	.....	1.50	.....	.....			1.9	3.52	.....	.....	.....	.....	1.6	753	22.6	74	.....	0	.....	10	o
			29	2.5	64	3.0	610	.....	1.82	.....	2.07	.....			2.9	3.11	.....	.....	.....	.....	2.5	753	.....	.....	.....	0	.....	10	o
			29	3.4	57	3.9	.....	.....	.....	1.67	.....	.....			3.8	3.82	.....	.....	.....	.....	3.4	753	22.0	76	143	2	.....	10	o
			29	4.3	80	4.9	683	.....	1.78	.....	1.81	.....			4.8	2.84	.....	.....	.....	.....	4.3	753	22.4	76	132	1	.....	.....	o
			29	5.3	71	5.8	.....	.....	.....	1.63	.....	.....			5.7	3.82	.....	.....	.....	.....	5.3	753	22.2	76	143	3	.....	.....	o
			29	6.2	60	6.6	769	.....	1.73	.....	1.56	.....			6.5	3.79	.....	.....	.....	.....	6.2	753	22.6	75	154	3	St-Cu	9	o
			29	7.0	3	.....	.....	.....	.....	.....	.....	.....			.....	.....	.....	.....	.....	.....	7.0	753	23.3	.....	143	3	Ci, Ci-Cu	.....	bc
2.4 N	273.6		30	9.9	57	10.2	631	517	1.39	1.27	1.53	1.71	5.1	1.7	14.6	3.62	.....	.....	.....	.....	10.2	754	25.6	79	199	3	.....	10	o
2.0 N	275.7	Oct	1	9.8	131	11.8	.....	.....	1.53	1.45	.....	.....	.....	.....	14.3	4.07	.....	.....	.....	.....	10.2	754	26.5	78	210	2	.....	6	bc
2.8 N	277.7		2	9.6	106	10.3	564	432	1.93	1.91	2.38	3.07	.....	.....	15.2	3.47	.....	.....	.....	.....	10.0	754	26.4	79	187	5	.....	3	bc
3.8 N	279.7		3[2]	12.0	87	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	12.4	752	26.8	81	208	4	St	10	o
6.4 N	281.6		5[2]	9.5	120	10.0	.....	.....	1.90	1.69	.....	.....	14.4	4.8	13.7	3.58	.....	.....	.....	.....	10.0	754	27.5	77	264	1	.....	7	bc
7.8 N	281.1		6[2]	9.7	64	10.3	.....	.....	1.91	1.63	.....	.....	.....	.....	15.0	3.65	.....	.....	.....	.....	10.2	752	29.0	78	207	2	.....	10	o
Balboa, Canal Zone																													

* Curie×10^-18 per cubic centimeter. [1] No potential gradient for several minutes during middle of set. [2] Main engine running.

CRUISE VI, ATLANTIC OCEAN, 1921.

°	°	1921		h	$\left(\frac{v}{m}\right)$	h	$\left(\frac{ions}{cc}\right)$		(ESU×10^-4		$\left(\frac{cm/s}{v/cm}\right)$		(ESU× 10^-7)	$\left(\frac{\alpha\times10^{-16}}{cm^3}\right)$	h	$\left(\frac{ions/cc}{s}\right)$	h	$\left(\frac{ions/cc}{s}\right)$	m	°	h	mm	°	p.ct.	°				
Cristobal, Canal Zone																													
11.3 N	282.1	Oct	21	9.6	100	10.3	609	475	1.32	1.11	1.51	1.62			15.0	4.39					10.7	752	28.6	73	161	5		10	o
12.3 N	284.0		22	10.2	104	[1]10.4	876	649	1.72	1.37	1.37	1.47			15.4	3.94					11.0	754	28.8	79	48	1		7	bc
14.6 N	284.5		23	8.3	131	9.1			1.37												8.3	754	29.4	72	92	5			bc
			23	9.5	134	10.1				1.06											9.5	754	29.3	76	92	5			bc
			23	11.0	159	11.6			1.39												11.0	754	29.4	69	92	5			bcrq
			23	12.1	176	12.7				0.92											12.1	754	30.4	72	92	4			bc
			23	13.2	167	13.9			1.18												13.2	754	29.8	72	92	4			bc
			23	14.4	180	15.2				0.96											14.4	754	29.7	64	92	4			bc
			23	15.6	136	16.2			1.22												15.6	754	28.5	73	103	4			bc
			23	16.6	138	17.2				0.91											16.6	754	28.2	75	92	4			bc
			23	17.7	111	18.3			1.42												17.7	754	27.7	77	92	4			bc
16.0 N	284.5		23	18.7	107	19.2				1.12											18.7	754	27.7	77	92	4		1	b
			23	19.7	100	20.2			1.43				9.9	3.3							19.7	755	27.7	77	92	4		0–1	b
			23	20.6	105	21.1				1.09											20.6	755			92	4		3	bc
			23	21.5	114	22.0			1.39												21.5	756	27.6	82	92	4		0–1	b
			23	23.1	124	23.6				1.10											23.1	755	27.0	85	81	2			bc
			24	0.0	90	0.5			1.34												0.0	755	27.4	84	81	4		1	bcqr
			24	0.8	94	1.6				1.14											0.8	755	27.4	77	103	4		0–1	b
			24	2.1	105	2.7			1.36												2.1	754			103	4			bc
			24	3.2	100	4.0				1.18											3.2	753	28.3	75	103	4			bc
			24	4.8	102	5.4			1.39												4.8	754	28.4	69	103	4		2	bc
			24	5.9	105	6.3				1.37											5.9	754	27.4	76	103	4			bc
			24	6.8	106	7.6			1.51												6.8	755	28.0	78	103	4		1	b
			24	8.0	109	8.4				1.23											8.0	755	29.4	82	103	4		2	bcr
18.9 N	285.5		25	10.0	106	[1]10.3	604	497	1.37	1.20	1.57	1.68	9.1	3.0							10.5	754	30.7	60		0		3	bc
20.6 N	286.0		26[2]	10.0	164	10.1	516	380	0.98	0.96	1.32	1.76	10.6	3.5	11.7	3.98					10.5	754	29.1	73	180	3		2	bc
22.8 N	286.7		27	9.6	117	10.4	622	562	1.19	1.06	1.33	1.31			14.2	3.65					9.9	753	29.5	68	246	6			bcr
24.6 N	286.7		28	9.8	170	10.4	739	573	1.73	1.44	1.63	1.75			14.3	3.94					10.3	752	28.0	76	324	7		5	bc
24.9 N	285.4		29			10.6	837	566	1.86	1.54	1.54	1.89			14.3	3.47					12.3	756	26.0	76	66	4		8	bcqr
26.6 N	284.7		30	9.6	139	10.3	805	512	1.63	1.27	1.41	1.72			12.1	4.09					10.1	758	28.0	59	77	3		2	bc
28.5 N	284.9		31	9.5	144	10.2	666	563	1.67	1.18	1.74	1.45			12.2	4.36					10.0	757	26.0	68	133	4			bc
31.1 N	285.2	Nov	1[3]	7.1	104	7.7			1.40												7.1	752	23.5	83	244	4	St	8	e
			1	8.2	104	9.0				0.88											8.2	752			266	2		9	crq
			1	9.6	[4]187	10.2			0.98												9.6	752	25.0	70	244	2		1	b
			1	10.7	139	11.3				0.87											10.7	752	26.5	61	244	4	Cu	1	b
			1	11.8	150	12.9			1.21												11.8	752	24.8	64	244	4		6	bcuqr
			1	13.6	125	14.2				1.11											13.6	751	23.7	67	244	5	Ci–Cu, St–Cu	5	bcqr
			1	14.7	155	15.3			1.20												14.7	751	24.6	62	244	5	Ci	1	b
			1	15.8	126	16.5				0.97											15.8	751			244	5	Ci, Cu	1	b
			1	17.1	111	17.7			0.97												17.1	751			244	6	Cu, Ci–Cu	3	bc
32.9 N	285.5		1	18.2	116	18.7				0.98											18.2	751	22.8	59	244	6	A–Cu	2	bc
			1	19.2	106	19.8			0.92												19.2	751	22.7	58	244	6		3	bcr
			1	20.2	91	20.8				0.92											20.2	751	22.5	61	244	6		1–2	b
			1	21.3	116	22.1			1.11												21.3	751			244	6		0–1	bcqr
			1	22.6	89	23.2				1.16											22.6	750	22.3	64	232	7		0–1	b
			1	23.7	91	24.2			1.23												23.7	750	22.4	60	221	7		0–1	b
			2	0.7	96	1.5				0.98											0.7	750			221	7		0–1	b
			2	2.1	[5]104																2.1	748			221	7			bcqrl
33.6 N	286.1		3	9.5	[1]131	10.6	607	376	1.24	0.94	1.42	1.74			15.1	4.36					10.1	756	23.3	67	242	1		5	bc
35.2 N	286.3		4			[1]10.7		195	0.68	0.58		2.06									10.7	759	17.7	59	319	4			bc
36.5 N	285.4		5	9.3	198	11.7			0.61	0.52											10.2	755	16.5	67	297	7		1	bcz
37.0 N	283.9		6[6]	8.7	176																8.7				18	3			b
Washington																													

*Curie×10^-18 per cubic centimeter. [1] Main engine running. [2] Cuba 20 miles distant. [3] Heavy rain storms during previous night. [4] Rejected on account of heavy rolling and just after heavy rain. [5] Interrupted by rain storm. [6] In Chesapeake Bay.

EXTRACTS FROM INSTRUCTIONS FOR ATMOSPHERIC-ELECTRIC WORK, 1915-1921.

The following extracts from official instructions for atmospheric-electric work to those in command of the *Carnegie* will indicate the program of atmospheric-electric work carried out daily on board.

GENERAL INSTRUCTIONS, CRUISES IV, V, AND VI, 1915-1921.

The instructions for Cruise IV issued to J. P. Ault at Brooklyn, February 1915, and those for Cruise V, issued to H. M. W. Edmonds at Buenos Aires, December 1917, were practically the same as those prepared later for Cruise VI, issued to J. P. Ault at Washington, October 1919, which are given in detail on the following pages. Some slight modifications and additions were made owing to the adoption for Cruise VI of a more intensive diurnal-variation program and to certain changes and improvements in the methods and instruments as indicated from observers' experience on cruises IV and V. The "Directions for Atmospheric-Electric Work, Cruise VI" were as follows:

1. The work comprises measurements of the following:

(*a*) Conductivity (positive and negative), λ_+ and λ_-.
(*b*) Number of positive and negative ions per cubic centimeter, n_+ and n_-.
(*c*) The potential gradient, *P*.
(*d*) The radioactive content of the atmosphere, *Q*.
(*e*) The penetrating radiation, *R*.
(*f*) The diurnal variation of the potential gradient, positive ionic content, penetrating radiation, and, when possible, the positive conductivity.[1]
(*g*) The meteorological elements: pressure, temperature, and relative humidity.

2. The method of taking the observations is arranged so that the elements are obtained, as nearly as possible, simultaneously. Thus, for example, a second observer measures the potential gradient during the measurements of the conductivity by the first, and as a result it becomes possible to calculate the air-earth current-density *i*.

3. It would be desirable for the collection of the active deposit in the radioactive determinations to extend over the whole period of the conductivity observations, but as this would involve too great a use of current in the motor driving the fan, it will be necessary to collect active deposit for only half an hour towards the end of the conductivity observations. On the completion of the conductivity observations, the active foil may be removed from the radioactive-content apparatus and the decay-curve observations taken. After the first few minutes of the decay-curve observations the observations of the penetrating radiation may be commenced and carried on simultaneously with the decay-curve observations. Thus, for example, if λ_+ is first measured there will be an initial leak-observation for λ_+ and n_+ lasting, say, 5 minutes. The main observations for λ_+ and n_+ will then be taken lasting, say, 10 minutes, after which a second leak-observation similar to the first will be taken for each element lasting, say, 5 minutes. Leak-observations for λ_- and n_- will then be taken, then the main observations for λ_- and n_- (20 minutes), and then another leak-determination for each element. Finally the whole set (including leak-tests) will be made again for λ_+ and n_+ (20 minutes). The collection of the active deposit should be commenced, in the above case, after the second determination of the leak in the measurement of the negative ions, i. e., just before the last set of observations corresponding to the positive ions. The main observations and the leak-observations in this last set will require about 20 minutes, so that it will be possible to stop the collection of the active deposit half an

[1] On March 15, 1921, these instructions were amended to include diurnal variation of both λ_+ and λ_-.

hour from the commencement of the collection and immediately to take the activated foil to the ionization chamber.

4. The observations for the decay-curve should extend over an hour and a half at least, and it may be desirable occasionally to extend them over a longer period.

5. The meteorological observations should be taken by the second observer immediately after the commencement of the collection of the active deposit.

6. The whole set of observations will thus occupy about 3 hours and should be commenced at 9 a. m.

7. Twenty-four-hour series should be made whenever possible to obtain the diurnal variations of the potential gradient, positive ionic content, and penetrating radiation. If possible, the positive conductivity should also be included, and even if it is impossible to make measurements of all four elements on the same day, about half of the sets of runs for the penetrating radiation should be sacrificed in favor of the positive conductivity.

8. The days chosen for diurnal-variation runs should be varied so as to obtain records corresponding to different meteorological conditions. However, no days especially bad from the point of view of rain, storm, or similar conditions, should be chosen.

THE CONDUCTIVITY AND IONIC CONTENT.

9. A description of the apparatus and methods will be found in Volume III (pp. 382–389).

10. The general scheme in the two instruments to be used involves allowing the fiber to move over a fixed range, the time required being measured in the case of the conductivity apparatus and the total air-flow in the case of the ion counter. The fixed ranges may be determined directly in volts by means of the calibrating-potentiometer systems which have been provided for this purpose.

11. The sensitivity of the ion-counter electrometer should be about 5 to 10 scale-divisions per volt, and the magnitude of the fixed range should, in general, be 4 or 5 divisions. The sensitivity of the Wulf electrometer associated with the conductivity apparatus is about 1 division per volt. The instrument is supplied with an auxiliary case which may be insulated and raised to any desired potential so as to cause the fibers to record on the most sensitive part of the scale. In general, however, it is not necessary to make use of this subsidiary case and it should then be connected electrically to the earthed outer case.

12. The initial potential V_1, to which the central system of the conductivity apparatus is charged, should not be too low or the apparatus will be insensitive. On the other hand, it must not be too high or the instrument will give inaccurate results.

If U is the volume of air flowing through the conductivity apparatus per second, n the number of ions per cubic centimeter, k the specific velocity of the ions, C_2 the capacity of the portion of the insulated system exposed to the air-current, the maximum allowable value of V_1 is given by

$$4\pi C_2 V_1 nk = Un \qquad \text{whence} \qquad V_1 = \frac{U}{4\pi C_2 k}$$

in which k may be taken as 1.3 centimeter per second per volt per second (i. e., 390 centimeters per second per electrostatic unit), C_2 is known, and a lower limit may be obtained for U by multiplying the cross-sectional area of the outer cylinder of the conductivity apparatus by the air velocity as determined by the large anemometer.

It will, in general, be safe if the value of V_1 used does not exceed 75 per cent of the value calculated as above. The subsequently computed value of k will show whether on any given day, owing to some abnormality, the critical value of V_1 has been exceeded.

Variation in U is the factor which is most likely to cause the maximum allowable value of V_1 to vary. U may vary with the wind-strength, with the direction in which

the funnel is turned in relation to the wind, and with changes in the motor. Whenever there arises any suspicion that U is below normal, a test should be made as described above.

13. The conductivity apparatus should first be turned so as to face the wind. Before making the leak-test with either instrument the air should be allowed to flow through the instruments for several minutes so that the insulating material may attain that degree of dampness which it will have during the experiment. The fans are then to be stopped. By means of the calibrating attachments the insulated systems of both instruments are to be charged to potentials which correspond approximately to the midpoints of the respective fixed ranges, or, rather, to potentials a little different from these values in the sense to insure that, during the leakage test, the fiber will travel as far on one side of the true midpoint as on the other. In order to avoid erratic initial effects the first fiber readings of the leak-tests should not be made until about one minute after the preliminary adjustment of potentials. The second readings should be taken several minutes later. Leak-periods of 100 or 200 seconds facilitate the computational work based on these observations. The deflections and time intervals observed during leak-tests should be recorded as Θ_1 and Δt_1, respectively, on Form 101.

14. The fans of the two instruments are next to be started, the conductivity apparatus recharged to the potential V_1, and the ion-counter fiber released from earth. The conductivity apparatus reading and the time are now to be taken and, when the ion-counter fiber has gotten to its first fixed mark,[1] the meter is to be read. When the ion-counter fiber has gotten to its next fixed mark, the meter is read again, and by this time the conductivity-apparatus fibers should be approaching their second fixed marks. When they reach these marks the time is again read. The conductivity apparatus is then to be recharged to V_1, the ion counter is earthed, V_1 is read, and the observations gone through as before. The procedure is repeated in this way until at least *three* determinations have been made for each element. The second leak-test is then to be taken in exactly the same manner as the first. The charge on the central cylinder of the ion counter is then to be reversed, the charge on the conductivity apparatus is reversed, and the whole operation, including initial and final leak-tests, is to be gone through for the ions of opposite sign, twice as many sets of determinations being made, however. The charges are then again to be reversed, and the whole operation repeated for the ions of the first sign, making the same number of sets of determinations as previously made for this sign.[2]

Just before making the first leak-test for the second set of determinations the second observer should receive a signal to commence the measurement of the potential gradient, and he should continue these measurements at intervals of one minute until the completion of the second leak-test for the middle set of observations of λ and n.

15. Days on which there are two sets of determinations of λ_+ and n_+, and one set of determinations of λ_- and n_- should alternate with those on which there are two sets of determinations of λ_- and n_- and one set of determinations of λ_+ and n_+.

16. In order to determine for the ion counter the value of the fixed range in volts, the rheostat of the calibrating system is adjusted so that the fiber is on the lower fixed mark, when the voltmeter is read. The rheostat is then adjusted so that the fiber is on the upper fixed mark and the voltmeter read again. The difference gives the value

[1] The first fixed marks for the ion counter should not be chosen as the portion occupied by the fiber when earthed, as frequently a deflection occurs on releasing from earth. This may be due to inductive action, but may also result either from looseness of the metal plug supporting the fiber (or even of the amber insulator) or from having too stiff a spring on the contactor. The best condition is when the spring is just stiff enough to insure contact, but not enough to cause distortion of the fiber-supporting system. The first fixed mark should be about 0.5 division from the earthed portion. For this reason it will be convenient to adjust the scale so that, when the fiber is earthed, it appears about half-way between the two divisions.

[2] It should be noted that, in order to obtain λ_+, the inner cylinder of the conductivity apparatus is charged negatively, but in order to obtain n_+ the outer cylinder of the ion counter is charged positively. By the outer cylinder of the ion counter we always mean the one immediately surrounding the central rod.

of the fixed range in volts. Details of the calibrating system referred to above will be found in Volume III (pp. 383–384). In the apparatus as at present used, however, *one* calibrating system serves for ion counter, penetrating-radiation apparatus, and radioactive-content apparatus.

17. For supplying to the conductivity apparatus its initial potential V_1 and for determining the value in volts of its fixed range a 100-cell chloride-of-silver battery with individual cell terminals is supplied. During observations this battery is connected to the 150-volt range of the observatory voltmeter as well as to the electrometer of the conductivity apparatus. It is thus readily possible, by plugging in an appropriate number of cells, to determine a suitable working range for the fibers and the values in volts of the deflections involved. Care, of course, must be exercised not to short-circuit the battery and to keep the voltmeter in circuit no longer than necessary.

18. The ion counter should be kept as level as possible by hand when readings are being taken. The bifilar electrometer associated with the conductivity apparatus seldom shows effects of the ship's motion to an extent which would suggest the necessity of a gimbal mounting. While the actual *position* of the fibers changes slightly with the roll of the ship, the *sum* of the two separate readings usually remains constant for a given potential. When it appears necessary to do so, however, allowance for the inclination of the apparatus may be made as follows: The microscope should be adjusted so that the fibers stand at equal distances on each side of the zero when the base plate is horizontal and the position on the scale is about that corresponding to the actual measurements. When the ship inclines the fibers will give different readings, and the corrected position of the fiber whose readings determine the fixed range is to be obtained by adding or subtracting, as the case may be, half the difference in readings of the two fibers. Mistakes in the direction of applying the correction will be avoided if it be remembered that the correction always makes the fiber readings more nearly equal.

19. In recording on Form 101, *all readings should be recorded strictly in the order in which they are taken* to avoid the possibility of confusion. *This should be a general principle applying to all measurements.* Unless this matter is attended to carefully, it becomes difficult to check the observers' determinations of the signs of the leakage corrections.

20. Immediately after the completion of the potential-gradient observations (before dismantling the potential-gradient apparatus) the second observer should start the fans and replenisher connected with the apparatus for the radioactive content, and should read the meter associated therewith as well as the time in the manner more specifically dealt with in the instructions for the measurement of the radioactive content.

21. In part (1) of the "Memorandum Concerning Various Points Involved in the Atmospheric-Electric Measurements," dated October 6, 1916, is incorporated a full description of the arrangements for using a megohm in conjunction with the battery which supplies the plates of the unifilar electrometer.

22. Care must be taken to avoid putting a potential on the outer cylinders of either ion counter, penetrating-radiation apparatus, or ionization chamber of the radioactive-content apparatus when the fiber is not earthed. A similar remark applies on removing the potential. The outer cylinders of ionizing chambers should always be definitely connected either to the earthed case of the electrometer or else to the source of potential employed.

When the plate-terminals of the unifilar electrometers are joined by the megohm, there is no danger of injuring the fiber by disconnecting the battery from the plates. When the megohm is absent, however, the plates must be disconnected from the battery as nearly as possible simultaneously, after which they should be connected together for an instant.

23. The various drying-bulbs should be kept supplied with drying material, and should not be allowed to accumulate water. When renewing the drying material of the penetrating-radiation apparatus, especial care should be taken to avoid, as far as possible, the entry of new air.

The amber insulation should be cleaned when necessary. In case sea-water or any contamination gets onto the insulation at any time, and it is found that the trouble is not removed by alcohol, it will be well to try clean water and then alcohol, as some salts are soluble in water and not in alcohol. Amber surfaces are most effective insulators when they are well polished. All the various insulators were well polished and cleaned before being installed for the present cruise. In case they should become roughened by any means they may be polished by rubbing with a cork and jeweler's rouge. When this is done, however, care must be taken to remove all the rouge.

24. The Bureau of Standards calibration of the ion-counter anemometer, test 26699, will form the basis of corrections to be applied for the reduction of anemometer indications to absolute values. The calibration curve shows that for all meter-rates above 1.35 divisions per second the correction-factor for reducing ΔM to liters is 1.08. In order that the meter-rate shall not fall below 1.35 divisions per second the ion counter has been provided with a small funnel which is always to be turned *into the wind*. Even in a calm the use of the funnel will cause an increase in the rate of air-flow and consequently of the meter-rate. It is of course obvious that if the funnel is allowed to point away from the wind aspiration will diminish the air-flow to such a low value that the factor 1.08 will no longer apply. The quantity ΔM on Form 101 must, of course, be multiplied by the appropriate correction-factor (1.08 if rate is as great as 1.35 divisions per second) to secure the quantity W and hence W^{-1} of Form 101.

If it is found that there is considerable variation in the meter-rate, even though it is always above the critical rate (1.35 divisions per second) it will be necessary to take account of this variation in order that a proper leak-correction may be applied. To this end the highest and lowest actually occurring time rates of the meter should be noted and the quantity pt_m^{-1} of Form 101 computed for each. If the difference between these extremes forms not more than 2 per cent of the average W^{-1} it will be sufficient to adopt a mean value of p. Otherwise three values of p, corresponding to high, low, and average rates, should be computed and for each set of ionic-content observations that value of p should be used which observation indicates to be the appropriate one.

The anemometer of the ion counter may be removed by means of a threaded union and should occasionally be lubricated with a small amount of watch oil.

25. The various gimbals should be securely clamped when the instruments are not in use.

POTENTIAL GRADIENT.

26. A description of the apparatus will be found on pages 380–381 of Volume III. The apparatus is fixed permanently to the stern rail of the ship, with the exception of the disk and rod (hereafter to be called the prime conductor). On removal of the prime conductor the apparatus is to be covered with a specially waterproofed box provided for this purpose. The battery for the auxiliary potential is in the galvanometer house and is protected by a double-pole switch, which is also in the galvanometer house. When the prime conductor is nearly vertical it is earthed by touching the earthed brass plate of the base of the instrument. (This plate is to be always earthed by a wire connecting it to the copper sheathing of the vessel.) The reading of the electrometer (both fibers) having been taken when the prime conductor is earthed, the latter is turned so that the handle comes in contact with the fixed stop (see Fig. 4, Pl. 12), and the reading of the electrometer is again taken. The successive readings should be taken at intervals of about a minute and, so far as possible, when the base of the instrument

is horizontal. The prime conductor should remain earthed until it is seen, from sky-line observation or otherwise, that the horizontal position is being approached. It should then be noted that the position of the fibers corresponds to the earthed condition, after which the handle should be turned immediately and a second reading taken. In this way it can be arranged that the two readings are taken by approximately the same small amount on each side of the horizontal position. The observations should be taken alternately with the ship rolling from left to right and right to left.

27. If the interval between the two readings is small (and it will generally be about 1½ seconds) the leakage should be negligible. To test the leakage the prime conductor should be removed and the electrometer charged. The leak obtained under these conditions will appear, in view of the smaller capacity, of greater amount than in the actual experiment, and so it will be readily possible to estimate whether the leak during the process of turning the prime conductor is of importance.

28. It is not advisable to test for leak with the prime conductor attached, as fluctuations in the potential gradient will cause the electrometer reading to alter continually, and it will be impossible to ascertain whether such alterations as are observed are due to this cause or to leak.

29. The positions of the sails should, of course, be noted and recorded during the observations.

30. The sign of the auxiliary potential applied to the insulated case of the electrometer of the potential-gradient apparatus should always be recorded, and when no auxiliary potential is applied the auxiliary case should be earthed.

The sign of the potential gradient should always be recorded, positive when it is in such a direction as to drive negative electricity upward.

31. The electrometer used with the potential-gradient apparatus should be calibrated from time to time, making use of the portable Weston voltmeter. The calibration curve may depend, to some extent, upon the temperature, so that to follow this matter up calibrations should be made on days of widely differing temperatures.

32. Every opportunity should be taken of determining the reduction-factors for the potential-gradient apparatus, and in this connection, attention is called to page 382, Volume III.

RADIOACTIVE CONTENT.

33. A description of the apparatus and method will be found on pages 390–396, Volume III.

34. The water-dropper used with the apparatus should be supplied with a base potential of about 100 volts. The potential attained by the foil should be at least 2,000 volts (negative) and as much higher as possible. Fine wires, sharp edges, and points should be avoided.

35. At the completion of the potential-gradient observations, the second observer should start the collection of the active deposit. He should first start the water-dropper and, when the desired potential has been attained, he should start the fan and note the time of so doing, previously reading the meter. At the end of about half an hour the first observer will have finished his conductivity and ionic-number observations. Having taken the leak-test for the apparatus associated with the ionization chamber, the first observer should read the meter of the collection apparatus, and immediately earth the central conductor, noting the time of so doing. He should then stop the fan. He should remove the outer cylinder, take off the active foil, transfer it to the ionization chamber, and start taking observations for the decay-curve. The operations taking place between the cessation of the collection of the active deposit and the commencement of the observations within the ionization chamber should be *performed as quickly as possible*. The leak-test for the apparatus associated with the ionization

chamber should be completed, of course, before stopping the collection of the active deposit.

36. The active foil should be placed in the ionization chamber so that the active surface faces inwards and always in the same position, forming a kind of wide strip around the central regions, so that the distances from the top or bottom of the active part of the foil to the top or bottom of the ionization chamber is comparable with the range of the α-particles from the deposit. In this way the percentage of the α-rays which travel their complete range will be independent of the density distribution of the deposit on the foil. In so far as the portion of the foil which was nearer to the upper end of the collector cylinder contains the greater part of the deposit, it is desirable that when the foil is placed in the ionization chamber this portion of the foil be slightly nearer to the middle horizontal plane of the ionization chamber than the corresponding portion which occupied the lowest position in collecting apparatus. It is important under these circumstances that care be taken to see that the foil is always placed in the ionization chamber the right way round, i. e., with the edge which was at the top in the collecting apparatus always at the top in the ionization chamber, or if the edge is placed at the bottom in the ionization chamber it must *always* be at the bottom.

37. Care must be taken to avoid handling the active surface in its transfer from the collecting apparatus to the ionization chamber. The foil should be handled only by the inactive edges, which, in the collection apparatus, are shielded by the copper caps.

38. The sensitivity of the electrometer should be as high as possible (5 or 10 divisions per volt), and the electrometer observations should be taken as rapidly as possible at first, a range of about 3 divisions being used. The lower point should not be the earthed position of the fiber, but it should be slightly beyond, in view of possible inductive effects on removing the earthed connection. As the activity dies off the observations may be taken less frequently, although observations should be continued for 1.5 hours or more. A standardization of the fixed range completes the observations.

39. The factor k referred to in Form 103 (see Vol. III, p. 400) is to be taken as 5,000.

PENETRATING RADIATION.

40. The observations for the penetrating radiation should be started as soon as the observations for the decay-curve of the active deposit have reached a stage where they are taken about 5 or 10 minutes apart. The potential of the walls of the ionization chamber of the radioactive-content apparatus and that of the penetrating-radiation apparatus are both maintained by the same set of batteries. The potential should, of course, be applied to the penetrating-radiation apparatus at the same time as it is applied to the radioactive-content apparatus, since if it were suddenly applied to the former while observations were in progress with the latter the observations would possibly be disturbed for a short period.

41. The wooden cover on the roof over the apparatus should be removed, leaving only the thin copper cover. This may be done conveniently before the commencement of the whole series of atmospheric-electric observations.

42. The actual observations of the penetrating radiation simply involve noting the times taken by the fiber in moving over its fixed ranges. About 10 separate determinations will suffice for a series.

The amber surrounding the central rod is protected by an earthed guard-ring, which insures that leakage shall only take place as a result of the departure of the potential of the central system from the earthed value. The only practicable way of eliminating the residual leakage is to choose the fixed range so that it extends as far above as below the earthed position. For example, if the ionization chamber is positively

charged and the working range between fixed points of the scale is 0.4 volt, then the central system should initially be charged negatively to a potential of 0.2 volt by means of the calibrating potentiometer. When the central system is insulated any lack of proper insulation will accelerate the rate of the fiber's travel from −0.2 volt to zero and retard it from zero to +0.2 volt, thus eliminating leakage effects from the observation.

DIURNAL VARIATION.

43. If possible diurnal-variation runs should be made twice per month. It is desirable to choose days with a smooth sea, and on which the weather conditions are not abnormal (see section 8), and observations for each element observed should, if possible, be made hourly. In any case not less than 20 sets of observations should be made during a 24-hour diurnal-variation series.

METEOROLOGICAL OBSERVATIONS.

44. The relative humidity and temperature should be obtained with the sling psychrometer provided for the purpose. The barometric pressure should be obtained from the marine barometer, and should be corrected for temperature. (The remaining corrections will be made at the office.)

45. The method of recording clouds, wind, and weather should be strictly in accordance with the United States Weather Bureau's Instructions for Marine Observers, and the symbols indicated in those instructions should be adhered to (see p. 211).

46. Longitudes should always be recorded east of Greenwich.

MISCELLANEOUS MATTERS.

47. A complete set of sample computations will be found in the forms given in Volume III (pp. 397–401).

48. Care should be taken to see that the battery which drives the motors is properly protected by fuses, and it should be examined from time to time to see that no short-circuits are likely to develop. The main switch near the battery should always be turned off when the battery is not in use. The entire storage-battery circuit should be looked over occasionally in order to reduce to a minimum the short-circuits.

49. The commutator brushes and other wearing parts should be examined from time to time for wear, and the motors and fan bearings should be kept well oiled; occasionally, say when in port, the case inclosing the bevel gears which drive the fan of the radioactive-content apparatus should be removed and the gears cleaned, after which the case should be refilled with fresh grease ("Wolf's Head" grease is suitable).

50. The anemometer of the radioactive-content apparatus, as well as that of the ion counter, should be oiled occasionally with watch oil.

51. The copper gauze in the main cylinder of the conductivity apparatus should be cleaned occasionally, as small fibers and other particles may prevent a sufficient air-flow from being attained (section 11). If necessary the gauze should be removed for cleaning.

52. The miniature voltmeter in the observatory should occasionally be compared with the larger Weston instrument which serves as the ship's standard. The large voltmeter should not be left in the observatory while magnetic observations are under way. For the voltmeter comparison referred to above, the Edison primary battery should be used. This will limit the test to a comparison of the 3-volt ranges. However, since the per cent correction for the 150-volt range is the same as for the 3-volt range, it will not be necessary to make a direct comparison of the 150-volt ranges. In fact, such comparisons should be avoided, because of the very considerable drain on the silver-chloride batteries which would result from having the two voltmeters attached at the same time.

The 150-volt range of the standard voltmeter must be used, however, for the occasional calibration of the Wulf bifilar electrometers, but this is permissible, since the bifilar uses no current.

Whenever such tests are made, a record of the observations and method should be made and included in the cahier.

53. The first reading of the potential-gradient electrometer referred to in section 27 need not be recorded when the auxiliary potential is zero. However, when this is the case it should be stated definitely on the record sheet. When an auxiliary potential is used, the readings corresponding to the position when the prime conductor is earthed need only be taken at beginning, middle, and end of a set.

54. If any trouble is experienced with the bifilar electrometers, the observer should consult the "Memorandum Concerning the Atmospheric-Electric Measurements" dated October 21, 1916.

55. The ion counter should always be provided with its funnel when observations are being taken, and the potentials on the outer members of the three instruments, ion counter, penetrating-radiation apparatus, and ionization chamber of radioactive-content apparatus, should be at least 100 volts.

56. Of the atmospheric-electric observations outlined above, the most important at this stage are those of the diurnal variation. Of the diurnal-variation observations the most important are those of potential gradient, after which follow ionic content, conductivity, and penetrating radiation.

Of the regular daily observations the most important are potential gradient, ionic content, and conductivity; next follow, in order, penetrating radiation and radioactive content.

Regarding possible curtailment of work.—If the exigencies of the situation necessitate a curtailment of the program of the atmospheric-electric work, such curtailment should be made in accordance with the order of importance of the different measurements, as above noted.

SUPPLEMENTARY INSTRUCTIONS OF JULY 28, 1920, TO J. P. AULT AT FREMANTLE.

On July 22 the following cablegram was sent to Colombo:

> "Reductions indicate possible connection electric diurnal-variation and latitude. Desirable secure more diurnal observations even weekly if practicable curtailing regular electric work."

With data from something like 50 complete or nearly complete 24-hour runs available, it has now for the first time become feasible to separate the data according to high, middle, and low latitude belts.

While the various mean curves thus obtained are not supported by as large a number of observations as is desirable, there are nevertheless strong indications of differences in the mean diurnal-variation curves, especially for the potential gradient, with both latitude and time of year.

To make these curves more truly typical of the conditions they are supposed to represent, it is obviously necessary to secure a considerably increased number of diurnal-variation runs. The difficulties of making such observations are fully appreciated and the extent to which their frequency can be increased must be left entirely to the commander's judgment.

From the work on the *Carnegie* to date the general magnitude and distribution of each of the atmospheric-electric elements over the sea have been pretty well established. It is because of this fact that the greater emphasis should now be placed on the diurnal variation, even though it may be necessary to cut down considerably the number of regular forenoon sets of atmospheric-electric observations.

In view of the remarks contained in your letters of April 1, 1920, and April 30, 1920, concerning the potential gradient, and the evidence of special work done in this connection by the observers, it is believed they will take an especial interest in providing the additional data required for following up seasonal and latitude variations. No effort should be spared to secure additional runs in the maximum latitudes reached.

The importance of this increased work would be even greater if it should definitely turn out that the *position* of maxima and minima, as well as the absolute values, were undergoing variations, for in this case the relation between say a 9 o'clock value and the mean value of the day, for a given element, would be less definite than one might otherwise suppose. In fact, some evidence to this effect is found in the results of Mr. Thomson's special afternoon observations referred to above.

Besides the question of available time and man-power for additional diurnal-variation observations, the effect of increased wear and drain upon the instrumental equipment should also be taken into account as factors determining the extent to which it is feasible to go in the matter.

SUPPLEMENTARY INSTRUCTIONS OF AUGUST 19, 1920, TO J. P. AULT AT LYTTELTON.

Inspection of the atmospheric-electric data thus far received for Cruise VI makes it appear that perhaps an improvement can be secured in connection with the experiments for the determination of the radioactive content of the air.

For example, it is noted that occasionally a period of 8 to 10 minutes elapses between the time at which the collection of deposit is ended and the time when the first electroscope reading is taken, and corresponding periods of 5 or 6 minutes are very common.

Inasmuch as our determination of the radium emanation present depends upon analysis of curves, it is important to have points on these curves as soon as possible after the collection of deposit has ended. The curves are in general very steep during the first 10 or 15 minutes, and this accentuates the need for more data in this region.

Perhaps it should be recalled that for the purpose of analysis we require the value of η at 5 minutes and 20 minutes after end of collection and the slope of the curve at 22 minutes after end of collection. This makes it obvious how very undesirable it is to employ extrapolation to the time $t=5$ minutes. Unless the initial values scatter badly, it is not desirable to group them for mean values, since any η_o value determined from means can have little significance.

SUPPLEMENTARY INSTRUCTIONS OF MARCH 15, 1921, TO J. P. AULT AT SAN FRANCISCO.

Several lines of investigation make it exceedingly desirable that we have reliable data, in as large amount as possible, concerning the diurnal variation of atmospheric-electric vertical conduction-current. Thus far the only ocean data available have been those obtained on the assumption that variation of this current is practically identical with that of the product Pn_+ (Vol. III, p. 408) and thus far for Cruise VI, $P\lambda_+$. In order to secure actual observations of the variation of $P(\lambda_+ + \lambda_-)$, it is desirable that diurnal-variation observations for both λ_+ and λ_- be made. These observations should follow the general scheme of making two observations for λ_+, followed by four observations for λ_-, and closing with two observations for λ_+, or vice versa. It is not believed worth while to reverse the sequence from hour to hour, and it will be satisfactory if the same order is used throughout to simplify the observational procedure, although a *separate leak-test* should be made for the middle set of observations. If securing of both positive and negative conductivity observations involves too much time and energy on the part of the observer, or if the demand on the storage battery should be too great, it may be necessary to limit the number of sets obtained during a 24-hour run. This point must be left to the discretion of the commander and observer.

It will not be necessary to continue the diurnal-variation observations of n_+, although the morning observations should be made for n_+ as heretofore. If, in addition

to the above, the observer finds it possible to secure diurnal-variation observations of the penetrating radiation, these will prove of much more value at the present time than additional ionic-content data. Cruises IV, V, and VI to date have furnished a large amount of data on the diurnal variation of ionic content, whereas such observations for the penetrating radiation were obtained only during the first part of Cruise IV, and the amount of such data is very meager in comparison with that available for the other elements.

In view of the foregoing, certain sections of the "Directions for Atmospheric-Electric Work, Cruise VI," should be modified for use during the remainder of the cruise, to read as follows:

SECTION 7. Twenty-four-hour series should be made whenever possible in order to obtain the diurnal variations of potential gradient, positive conductivity, and negative conductivity. If practicable, the penetrating radiation should also be included.

SECTION 43. Diurnal-variation series should be made frequently—weekly, if practicable. It will, no doubt, be desirable to compensate somewhat for the extra labor entailed by these observations by a reduction of the number of regular forenoon sets of atmospheric-electric observations.

SECTION 56. Of the atmospheric-electric observations outlined above, the most important at this stage are those for diurnal variation. Of the diurnal-variation observations the most important are those of the potential gradient, positive and negative conductivity, and penetrating radiation.

It will be of interest to note that there is good agreement between the potential-gradient diurnal-variation curves obtained on Cruise VI in the Pacific and those obtained in the same region during Cruise IV. Comparison with the mean diurnal-variation curves obtained at the Apia Observatory, however, does not show, for the potential-gradient diurnal-variation curve, nearly so good an agreement with *Carnegie* values as there is among the various *Carnegie* series themselves. (It may be noted in this connection that the Samoa potential-gradient curve shown on page 419 of Volume III has been superseded, in later publications, by others whose forms are considerably different.) It seems worth while, therefore, that a special effort be made by the observers aboard the *Carnegie* to secure observations which may help to explain the apparent difference between *Carnegie* and Samoa results.

For instance, it may be that the conditions represented by the Samoa curves for 1912 and 1913 are the result of local peculiarities in the variation of the Earth's field. It would, therefore, be desirable to secure a diurnal-variation series, at least for the potential gradient, as the vessel approaches Samoa, say within the last 48 hours, and again as soon as practicable after she leaves.

In case the *Carnegie* anchors in the harbor of Apia, it will, no doubt, be possible to secure several diurnal-variation series of potential gradient. While it may not be possible to secure a reduction-factor to apply to these observations, they would nevertheless serve to give the form and general characteristics of the diurnal-variation curve.

In view of the fact that the Apia Observatory is the only one in the Pacific at which atmospheric-electric observations are being made, its work is of especial interest to the Department in the matter of control and comparison. It is hoped, therefore, that the atmospheric-electric observers on the *Carnegie* may find it possible to become thoroughly acquainted with the equipment and methods employed in the atmospheric-electric work of this station. Especial attention should be directed to distance between the potential-gradient apparatus and any disturbing factors, such as trees, prominent reefs, or rocks, and also to the variations of the contour in the neighborhood of the observatory with tidal phase. It is also of interest to learn the method by which the reduction-factor for this station was obtained.

It is barely possible that it may be worth while to secure an approximate reduction-factor for potential-gradient apparatus 2 at Apia, although from descriptions available this seems doubtful.

EXTRACTS FROM OBSERVERS' REPORTS ON ATMOSPHERIC-ELECTRIC MATTERS, 1915-1921.

Since many of the important comments and suggestions made in observers' reports during 1915 to the middle of 1916 on Cruise IV have been incorporated in the matter reported upon in Volume III (pp. 376–401) and in the instructions issued for Cruise VI (see pp. 266–276), only the more constructive ones are extracted here.

S. J. Mauchly: From Report of May 13, 1915, at Balboa.

Conductivity apparatus 3.—This apparatus differed from the usual Gerdien type by having the large cylinder above the roof of the observatory while the electrometer was inside the observatory, suspended from the roof by means of a gimbal mounting. Further, instead of the usual clockwork arrangement, a small electric motor was used to drive the fan.

By means of this motor, air is drawn through the apparatus five times as rapidly as with the clockwork. Since this causes a corresponding increase in the maximum potential allowable for correct results, it is now possible to use potentials high enough to bring the readings into the electrometer's region of maximum sensitivity without the use of an "auxiliary charge."

As a rule, potentials of about 100 volts were used. This is sufficiently high to make an auxiliary charge unnecessary, and is, at the same time, far below the critical value.

It was found that the gimbal mounting above referred to could not be unclamped at sea, except under extremely calm conditions, because of insufficient clearance between microscope and roof beams. However, this is of little consequence, as the Wulf bifilar electrometer is very little affected by the motion of the ship, even when on a rigid support.

The air drawn through the vertical tube leading from electrometer to large cylinder produced no measurable effect in discharging the central system. This was conclusively shown as follows: On a certain day the motor had been running for some time without producing any measurable effect on the potential. Examination showed that the central cylinder had not been put into position. Absence of any discharge of the electrometer showed that the effect in question did not exist.

The observed leak on this instrument seemed, as a rule, rather larger than we would expect. Since the opening between the vertical and horizontal cylinders above mentioned was about an inch in diameter, it allowed considerable dust to fall down upon the amber insulation in the vertical tube. Consequently, at Colon a brass plate, whose diameter was the same as that of the inner diameter of the vertical tube, was fastened by screws against the outside of the large horizontal cylinder. The opening through which the supporting rod for the inner cylinder of the apparatus passes was made 0.3 inch in diameter.

The introduction of this plate involved a change of electrical capacity. A determination made on April 5 showed that the capacity had been increased from 12.0 centimeters to 13.4 centimeters, which is the value used since the introduction of the plate.

By far the greatest difficulty experienced with the conductivity apparatus came from an entirely unexpected source. The motor, after having been carefully mounted and satisfactorily tried out, was removed from its position, first for the swing in Gardiners Bay and then daily during magnetic observations. The motor supports were

made with the idea that the mounting was to be permanent, and served well under those conditions. But after each removal it was found very difficult to fasten the motor securely and at the same time have its shaft coaxial with the fan shaft. Even a very slight departure from this condition would cause the motor to run hard. An ammeter showed that the power required to run the fan under these conditions was 25 to 100 per cent above normal.

In view of this increased wear on the fan and motor, and because of the extra drain on the battery and on the observer's time, plans were made to provide at Colon a flexible transmission to take the place of the rigid one. Before this work was taken up, however, it seemed worth while to make, in the absence of any disturbing influences, a thorough test of the magnetic effect of the motor. For this purpose the motor was taken to the magnetic station at Sweetwater Inlet. Dr. Edmonds, who made the test, reported the absence of any effect at distances greater than 3 feet.

Now, the minimum distance possible between motor and deflector is 9 feet, and the motor can always be swung around to a distance of 11 feet from the deflector during deflector observations. In view of the difficulties involved in providing suitable flexible transmission, and since the magnetic effect of the motor varies inversely as the cube of the distance, the result of the test seemed to Captain Ault to justify us in keeping the motor permanently mounted. Accordingly, this is the plan which was followed after leaving Panama.

Potential-gradient apparatus 2.—The ionium collectors used on previous cruises have given place on the present cruise to an apparatus depending upon the change in potential which an insulated conductor undergoes when it is moved in an electric field.

As used from Brooklyn to Balboa, this instrument gave sufficiently large deflections on electrometer 3995 (Wulf bifilar) to bring the readings into the range of maximum sensitivity. It was, therefore, never necessary to use an "auxiliary charge." However, the auxiliary charge should be used whenever the sum of right and left deflections is less than 25 divisions, as the readings of 3995 are not very reliable for such small deflections.

The sulphur insulation on this instrument proved entirely satisfactory. It never even became necessary to use the driers which had been provided. On the other hand, the hard-rubber insulation used for the handle needed to be carefully watched. However, when the instrument did show a leak, this would disappear, regardless of weather conditions, as soon as the hard-rubber surfaces of the operating lever were well cleansed with fine emery cloth. This had to be done twice on the first leg of the cruise.

Each morning the observer first tests the apparatus for leakage by using a 100-volt Zamboni pile. If leak is present, the rubber is treated as above indicated to remedy the trouble. This test is made before the time for actual observations and also before the prime conductor is mounted.

It was found that the ship's rail between the observer and instrument made it unnecessary to mount the wire screen which had been provided to prevent inductive action due to the movements of the observer; consequently, the screen was not used.

Penetrating-radiation apparatus 1.—The ionization chamber is somewhat larger than those usually employed, having a volume of about 22 liters. The potential is supplied to this ionizing chamber instead of to the central rod. This makes it possible to use a sensitive single-fiber electrometer instead of a less sensitive kind, as must be done where the potential is applied to the central system.

On leaving Brooklyn this apparatus seemed to be the one most likely to give trouble, inasmuch as its fiber seemed to be by far the most unstable. At sea it was found to be almost impossible to make dependable observations on account of excessive vibra-

tion of the fiber; besides, taking the readings caused a great strain upon the observer's eyes.

Because of the high position and rather large weight of the copper ionization chamber, this instrument was much more unstable mechanically than the ion counter. It was decided, therefore, to first increase the stability of the apparatus as a whole. To this end a counterweight of 5 pounds was applied at the bottom. After this had been done it became possible, by means of adjusting the tension of the fiber and position of plates, to secure conditions under which reliable observations could be secured without discomfort to the observer.

Radioactive-content apparatus 4.—Instead of the Elster and Geitel method which was used on previous cruises, the apparatus now in use involves an adaptation of the method used in the conductivity apparatus and ion counter. A fan driven by a small electric motor draws air between two concentric cylinders, the inner one of which is maintained at a high negative potential by means of a water-dropper. The radioactive deposit is collected on the convex surface of this charged cylinder. This surface consists of a thin sheet of copper and is removable. The ends of the inner cylinder are prevented from collecting deposit by two earthed caps which, of course, are not in contact with the cylinder. After the deposit is collected, the copper sheet is removed from the inner cylinder and placed in the ionization chamber with the side bearing the deposit turned inward. The ionization chamber is mounted above a single-fiber electrometer, and the potential is applied, as in the case of the penetrating-radiation apparatus, to the chamber, and not to the central system.

After the ship had gotten out to sea, several adaptations and changes proved to be necessary before the apparatus was in shape for successful tests on board ship.

The water-dropper which was used to charge the central system needed on one occasion to have its insulations renewed. After the insulation had been renewed, it was found possible to charge up the Braun electroscope to over 2,000 volts so long as connection was not made with the central system, but with the central system connected no charge could be accumulated. In due course of time the entire central system had been separated into parts so that each part of the insulation could be separately tested. With one exception all insulations were found to be perfect; but even after this was remedied, it was not possible to charge the central system.

It was then noted that so long as the earthed end-caps of the central cylinder were not in position the system could be charged. Since there was no possible chance of contact between these caps and the central cylinder, a microscopic examination was made to find the cause of leak. It was found that minute hairs, probably from sails and ropes, were collected on the inner cylinder, and when the cylinder was charged some of these hairs would stand up and establish electrical connection between the earthed caps and the charged cylinder. It was found impossible to remove all the hairs, so the ends of the cylinder were shellacked and polished in hope that this would remedy the difficulty. While it was found possible, by this means, to charge the cylinder initially, yet, after air had been drawn through for only a short time, the charge would leak away very rapidly.

It was then decided to diminish slightly the diameter of the central cylinder. By this time we were only a few days from Colon. Since the work of cutting down the cylinder without the use of a lathe was rather difficult at best, it was decided to defer this work until after reaching port. In Colon Harbor the diameter of the cylinder was reduced from 4.75 inches to 4.62 inches; as the inside diameter of the end caps is 4.87 inches, this now gives an eighth-inch space between the flange of the cap and the inner cylinder. The faces of the caps are 0.09 inch from the ends of the cylinder, as before. After this change had been made, several preliminary tests showed that a charge could now be maintained on the central system while the fan was running.

Auxiliary apparatus.—A system which was installed for the calibration of electrometers worked very satisfactorily. Similarly, the lighting system for night observations made it possible to make such observations without serious difficulties.

H. F. JOHNSTON: FROM REPORT OF JUNE 7, 1915, AT HONOLULU.

After the first day, when considerable time was spent in adjusting the various instruments and electrometers, complete observations were made except on a few occasions. The value of the conductivity was not obtained in the 4^h observation on May 4, when the insulation had completely broken down owing to the night-air dampness. Also, on six days there were no observations for radioactivity when either rain caused bad insulation or it was not possible to secure a proper potential. Also on one day the fan axle heated and prevented the observation. Observations for all the elements extending over 24 hours were taken five times. On four occasions sea-water was evaporated and the radioactivity of the residue tested, but at no time was there any trace of radioactivity. The small evaporating apparatus which is supplied with Wulf electrometers was used for the first three observations. Then it was thought that perhaps the quantity of sea-water evaporated had not been sufficient to obtain a detectable amount of the radioactive substance. Accordingly, a new evaporating can was prepared which is identical in size with the ionizing chamber of the radioactive-content apparatus. This large can was used for the last experiment, but as noted above there was no trace of radioactivity. On May 7 and 8 a few observations of the penetrating radiation were made with the permanently sealed vessel and also with the alternate vessel into which the air of the locality had been admitted.

The potential-gradient apparatus has worked very well, and beyond scraping the sulphur surfaces a few times nothing else has been necessary. The sulphur insulation around the axles has cracked, but it may not be necessary to renew it before reaching Dutch Harbor. The wires on the prime conductor had to be tightened and several replaced by slightly stronger wire. Owing to the low potentials encountered on leaving Balboa, it was found necessary to use an auxiliary charge (positive). The average potential gradient was slightly over 100 volts. On April 27 very abnormal potentials were encountered, the low value of 67 volts and the high value of over 1,150 volts per meter being obtained.

The radioactive-content apparatus worked very well, except when there was a slight rain, at which time it was almost impossible to keep up the insulation. After a series of experiments with various sizes of nozzles and streams of water, it was possible to maintain a steady potential of over 2,500 volts (divisions 43 to 48 by Braun electroscope) on the collecting foil. The potentials are not noted on the sheets, but after the first days it can be safely assumed that the average charge was 45 as indicated by the Braun electroscope. The base of the collecting apparatus has not proven to be sufficiently rigid, and the sulphur insulations have cracked, so that it will be necessary to renew them here. Shortly after leaving Balboa the batteries giving the charge to the electrometer plates failed, and it was overcome in the following way: One of the plates was connected to the same battery which supplies the charge for one plate of the penetrating-radiation apparatus while the other was connected to the battery of dry cells which was originally intended for use with the conductivity apparatus. So far this has been very satisfactory. When the electrometer is so adjusted that the sensibility is six to seven divisions per volt, the effect of the roll is slight and the fiber is very stable. The clamping device does not hold the gimbal solidly enough and there is a constant slight motion which in time will wear down the gimbal-ring knife-edges. The results obtained on the cruise show a gradually decreasing value of λ as the distance from Balboa increased. The decrease in this value, however, has not been as great as

previous observations with the wire method, indicating that the collection of the radioactive material is more complete by the instrument now in use on the *Carnegie*.

The ion counter gave no trouble. Several times it was necessary to clean the small amber ring. Just a few days before arriving in Honolulu some of the Krüger batteries used for charging the plates failed, and it will be necessary to put new batteries on the plates. The intention is to use the new cadmium batteries to give the plate charge; however, if these are unsatisfactory the new battery of dry cells will be used. The rate at which the turbine draws air through the apparatus varies, as can be seen from various sheets of observations inclosed in the cahier of results. This rate has been found to depend on the force of wind, namely, the greater the force of wind, the smaller is the quantity of air drawn through. This difficulty could be in part overcome by the use of a small air scoop on top of the cylinder, the scoop being capable of rotation so that it could be turned toward the wind. Abnormal values of ionic numbers were obtained at 5^h00^m on March 23, caused no doubt by the kerosene lamp which was used to light the observing house. Since leaving Balboa two small glow lamps have been used for recording, thus eliminating the kerosene lamp and no further abnormalities have been observed in the night work. The ionic numbers and specific velocities are of the same order as have been observed over land.

Observations with the conductivity apparatus have been taken on all occasions except the one noted above. When the relative humidity has been over 80 per cent, especially during the night runs, there have been insulation difficulties. The brass plate placed in the vertical cylinder which connects the electrometer to the upper cylinder did not entirely eliminate chimney-effect, allowing a current of moisture-laden air to blow past and condense on the amber. The amber surfaces on being cleaned with alcohol soon became conducting. Better results were obtained after their surfaces had been carefully polished. It is rather awkward to remove the central system in order to clean the amber surfaces. Since the motor was permanently mounted in Colon, only occasional attention has been necessary to keep it in such adjustment as to use the minimum amount of current. It will be noted from the observation sheets that there are quite large variations in the leak, as it is not possible with the present apparatus to exclude all air drafts; the chamber inclosed during the leak-test also includes the box surrounding the motor. There is also a loss in accuracy, because the gimbal has to be clamped during observations.

An alteration in the apparatus would overcome some of the difficulties experienced with the present instrument. It could be made in two parts, the upper part having the large cylinder and motor attached, being capable of rotation on the outer fixed gimbal-ring. The upper part of the cylinder which connects the electrometer to the upper cylinder would be fixed to the outer gimbal and the upper amber insulation project slightly into the upper cylinder and fit into a collar attached to the upper cylinder. The electrometer and the lower part of the vertical cylinder would be attached to the inner gimbal-ring. The upper cylinder could be supplied with two close-fitting disks for the leak-experiment. Also, by the use of the same size gimbal-ring as that on which the ion counter is mounted there would be more space for the vertical connecting system. The upper cylinder need not have so much clearance as in the present instrument, thus cutting down the total capacity. In such an instrument there would be the following advantages:

1. The gimbal, being non-rotatable, could be left unclamped.
2. Better facilities for the leak-test.
3. Only one amber surface exposed to the air-current, and this surface easy of access.
4. Elimination of chimney-effect.
5. Slight decrease in capacity of the system.

The penetrating-radiation apparatus worked well throughout the trip. Toward the latter part of the trip the value of R was almost constant at 3.4. Several experiments were performed since arrival in port in order to determine the nature of the radiation. It was found that there was no diminution in the value of R when two pieces of sheet lead each 0.12 inch thick were placed on top of the cover and a sheet 0.06 inch thick placed around the can. Observations were also taken with the alternate can into which the air of the locality had been admitted. The value of R obtained with the alternate can on May 29 was constant at 8.2.

The various batteries of dry cells which are used to give static charges have deteriorated about 10 per cent. The battery which is used for charging the inner cylinder of the conductivity apparatus has become badly polarized and gives only 120 volts on open circuit, while on closed circuit the voltage falls quickly to below 60 volts.

H. F. JOHNSTON: FROM REPORT OF AUGUST 2, 1915, AT DUTCH HARBOR.

The effect of a heavy fog on the numbers of ions was shown in the observation July 18, which gave the low value 225 for the positive ions. On this occasion there was very heavy fog around the vessel. On account of the extreme dampness the insulation soon broke down and a determination of the number of negative ions was not made. Simultaneous values of the conductivity were also low, being 0.45×10^{-4} for λ_+, and 0.40×10^{-4} for λ_-.

A negative potential gradient was observed on two occasions, at 16^h48^m July 28 and at 9^h36^m July 30. At 15^h41^m July 28 there was a sudden change in conditions which markedly affected the potential gradient. Before 15^h41^m there was practically a calm. At 15^h41^m a strong breeze, locally known as a williwaw, which was moisture and fog laden, came up from the east, and the potential gradient increased immediately to about three times its former value. This wind was still blowing at 16^h33^m, but by this time the air had become much damper. The potential gradient was much smaller than it was at 15^h42^m, and it kept decreasing till 16^h46^m, when it went to the opposite sign, but at 16^h50^m it was again of the same sign.

H. F. JOHNSTON: FROM REPORT OF APRIL 15, 1916, AT LYTTELTON, N. Z.

I have to report as follows in regard to the atmospheric-electric work on the recent circumpolar cruise. Observations were obtained on all possible occasions. There were precipitations of some nature on 100 out of the 115 days we were at sea, so that on many occasions it was impossible to obtain observations and on others the observation time had to be shortened or the routine changed. On account of the bad weather the sets of continuous observations were fragmentary, nevertheless continuous work was done on fourteen occasions. We had very bad weather throughout the trip, but all the instruments were quite workable except the penetrating-radiation apparatus, which would bump on the frame on heavy rolls. It was found necessary to eliminate the observations for R in various continuous sets.

Seas were shipped over the atmospheric-electric house on two occasions during observations. With some difficulty the insulation was restored, but toward the latter end of the trip the upper amber of the connecting cylinder of the conductivity apparatus went bad and observations could not be taken. The upper amber plug of the ion-counter electrometer cracked on the surface and began to deteriorate, having the appearance of bubbles in the surface. The amber ring cracked also. It was accordingly advisable to cable for replacements for these two pieces as well as a replacement for the lower amber of the connecting cylinder of the conductivity apparatus. Mr. Jones arrived a few days later with the new amber connections for the conductivity apparatus. These will be installed and a new determination of the capacity made as soon as the Gerdien condenser arrives.

The following interesting points were noted on the trip: December 8 the potential gradient was very low. January 4 fog came in very thick during the observations and the ionic numbers decreased one-half. January 6 a much larger amount than usual of radium was collected, due perhaps to the prevalence of a wind from South America. January 19 fog came in heavily during the determination of the ionic numbers and the ratio of n_+ to n_- was quite large. January 25 there was a sudden rise in the potential gradient as a snow squall hit the ship. February 6 a negative potential-gradient was observed. March 28 the observations for the radioactive curve were continued over a long period, the radium being collected under sea conditions. By March 30 we were off the coast of New Zealand and a large amount of radioactive mater al was collected and a long-period curve determined. A comparison of these two curves should show up the difference between the radioactive substances as obtained at sea and on land.

A. THOMSON: FROM REPORT OF NOVEMBER 24, 1919, AT DAKAR.

Conditions were unfavorable for the carrying out of the atmospheric-electric program. The usual stormy weather of the North Atlantic was encountered and rain squalls in particular interfered with the work. Potential gradient was obtained 30 days, ionic content 25 days, radioactive content 17 days, and penetrating radiation 27 days.

The silver-chloride batteries have so far been found very satisfactory. When tested on November 20 they were found to give the same voltages as were obtained on October 12, 1919. The Edison primary cells are standing up very well.

The lighting circuit for illuminating the scales of the different instruments in the atmospheric-electric house for night observations has been put up. Each light has its own switch, so that current need only be used for the brief time an observation is being made. The same Edison primary cells that are used to supply current to calibrate the ion counter, penetrating radiation, and radioactive-content apparatus are used in the lighting circuit.

The first troubles encountered with the potential-gradient apparatus were due to the sulphur and rubber insulations. The leak in the electrometer both on the upper and lower surfaces of the amber support for the fibers was always found to be either very small or non-existent. This was probably due to the continuous use of drying agents in the bulbs provided. Phosphorus pentoxide has been used in all instruments throughout the trip. The hard-rubber insulator separating the prime conductor from the handle was found to become conducting when wet by the very finest spray. It would appear possible to make up a shield for the insulator that might be fitted over the handle when spray or light drizzle is falling. The present insulator has been sandpapered and scraped so much that it might be well to have another made up and sent to Buenos Aires.

The sulphur insulation was at first found to give a good deal of trouble. Some impurities in the sulphur were probably responsible for part of the conductivity. There were a lot of black specks perhaps a millimeter square in the outer layers of the sulphur. After these particles were scraped away little trouble was experienced. The sulphur has been scraped away so much from around the axle carrying the prime conductor that it will have to be renewed before long. It is suggested that special pains be taken to get pure sulphur for insulating purposes.

The quantity of air drawn through the meter has been found always to be so large that it can safely be assumed the meter-readings should be increased by the factor 1.08 to give the true quantity in liters of air drawn through. A table has been made up for computing W^{-1} on this basis for meter-readings from 75 to 284. The rate at which air is drawn through, though high, was variable. It is this that determines the quantity p, the time for 1 c. c. of air to flow through apparatus. It was found necessary to draw

up a table giving the value of p for meter speeds from 75 to 120 per minute for every fifth integer.

In the radioactive-content apparatus all troubles were experienced with the collecting apparatus and none with the ionizing chamber or the radioactive-content apparatus electrometer.

The penetrating-radiation apparatus has been found to work very well throughout. The values of the penetrating radiation have been low, making one suspicious of leak, but they are believed correct.

A. THOMSON: FROM REPORT OF FEBRUARY 11, 1920, AT BUENOS AIRES.

The radioactive-content apparatus has given fairly good service. The fan was repaired at Dakar, but the bushing for the vertical fan shaft was too short. After some weeks' use the fan began to wobble. It was decided that the best remedy would be to extend the shaft so as to allow it to rest in an arbor in the bottom of the grease box. A new shaft was accordingly made and it has been found to give good satisfaction. The water jets occasionally give trouble, but patient adjustment seems the only remedy. The sulphur insulation for the support for the copper foil has been renewed here. The electrometer and ionization chamber in the atmospheric-electric house have worked quite well during the cruise.

The silver-chloride batteries have given good satisfaction and those in use (1, 2, 3, 4, 6, and 7) give 30.8 volts on Weston voltmeter 33657. This is about the same value as was given on leaving Washington.

The sulphur insulation around the axles of the support carrying the prime conductor was renewed here. In general, favorable weather was experienced during the past two months, so that little trouble was experienced with leak in the potential-gradient apparatus. Practical difficulty presents itself in reading the instrument the instant the ship is on an even keel. The observer's attention must be focused on the fibers in order to read them simultaneously and it is almost impossible at the same time to sense just when the ship is on even keel. As a general rule the maximum deflection of the fibers is read, avoiding of course exceptionally high readings when the ship's stern is on the crest of a wave.

A. THOMSON: FROM REPORT OF APRIL 1, 1920, AT ST. HELENA.

For 10 days the potential gradient was observed in the late afternoon (about 16^h25^m) as well as in the morning and on 9 days two determinations of the potential gradient were made in the morning. It was found that the two morning determinations taken less than half an hour apart gave approximately the same value. Since they were not on the regular program and as a difficulty arose as to the value to use in computing the air-earth current-density, only one determination of the potential gradient is now being made in the morning. It is hoped to continue taking the potential gradient in the afternoon. On 9 out of the 10 days the afternoon value has been found to be greater than the morning value.

From February 26 until March 13 the *Carnegie* was south of 35° south latitude. During this time the humidity was high and the weather generally cold and disagreeable. It required a good deal of extra work keeping the insulation on the instruments sufficiently good. During the rest of the cruise the humidity has averaged about 75 per cent and there has been considerable sunshine. These circumstances have made it much easier to carry through the daily program of observations.

A. THOMSON: FROM REPORT OF APRIL 30, 1920, AT CAPE TOWN.

The increase in the radioactive content of the atmosphere near land was clearly shown during the approach to Cape Town. On April 13, six hours after a very heavy thunderstorm, the positive ionic content was only 55 per cent of the negative ionic

content. The air-earth current-density shows a tendency to remain constant for a number of days, although both the conductivity and the potential gradient may vary considerably.

The weather was marked by exceptional cloudiness and frequent showers of rain. In spite of the high humidity the instruments have worked satisfactorily. There have been no fibers broken or any evidence shown of the conducting layer breaking down. The silver-chloride batteries are giving their full potential and show no signs of deterioration. In this regard it may be of interest to state that battery 8, used as an auxiliary potential for the potential-gradient apparatus, has had hard service and has stood up well.

A. THOMSON: FROM REPORT OF APRIL 15, 1921, AT HONOLULU.

The potential-gradient apparatus has given good service. The sign of the potential gradient was postive at all times. Whenever the potential gradient was low during the diurnal observations, time was taken off to make sure that it was not due to bad insulation. On account of the short stay at Honolulu and the rocky character of the coast line, it is impossible to make a determination of the reduction-factor.

The values obtained for the ionic content have been, in general, lower than those previously obtained. In order to make sure that there was a sufficiently high charge applied, a few experiments were carried out, the results of which are given at the end of the daily observations for April 2. The potential from three, four, and the equivalents of five battery boxes was applied to the outer cylinder, requiring very considerable adjustment to the electrometer. The values obtained did not vary over 2 per cent.

A. THOMSON: FROM REPORT OF JULY 12, 1921, AT APIA, SAMOA.

On July 5 reduction-factors were determined for the potential-gradient apparatus for two positions of the boom and mainsail.

About 0.75 sea-mile to the north-northwest from where the *Carnegie* was lying at anchor and 0.6 mile east of the observatory at Mulinuu is a coral reef. This reef is submerged at high tide, except for a small stone structure 15 feet square. The containing walls of this structure are made of pieces of rock and the inside filled with earth. Two dwarfed palm trees are growing in this earth. These trees are small and less than 10 feet high.

At low water, which is 3.8 feet lower than high tide, several acres of rock are exposed. The area is V-shaped with a ridge running down the center of each arm of the V. The height of this ridge was less than 2 feet above extreme low water. The ground was fairly smooth and made up of small branches of coral, scattered with small slabs of coral rock.

On July 4 the reef was examined and a position selected on the arm of the V farthest out to sea. The site was 100 yards away from the stone structure on a level stretch near the ridge of the exposed area. On July 5 the apparatus used in the Simpson stretched-wire method was put in the dinghy and taken to the reef. Wulf electrometer 4357 was used to measure the potential. The wire and collectors were the same as used at Solomons Island in 1919. The sulphur insulators had been previously cleaned and melted sulphur poured in. The sulphur surfaces were again scraped. The posts were made of 0.75 inch by 2.5 inch material 4 feet 3 inches and 4 feet 9 inches long, respectively. The ends of the posts were put into shallow holes in the rubble of the beach and securely guyed by ropes. The wire carrying the two collectors was stretched taut. During the time of observation the wire elongated considerably, due to heat and tension. The surface directly below the collectors was carefully leveled off for several square meters. The height of the collector was measured at the beginning and end of each of the sets. At the close of the first set the wire was tightened and the collectors raised from 0.99 meter

to about 1.10 meters. Apart from this there was no alteration whatever in apparatus between the first and second sets.

There was a light trade-wind blowing which caused the collectors to bob up and down through a maximum range of 2 centimeters. The collectors also rotated around or with the wire perhaps 45°.

Electrometer 4357 was mounted on a wooden box about 50 centimeters high and one meter distant from one of the posts to which the wire carrying the collectors was fastened. Connection was made to this wire by a fine copper wire from which the cotton insulation had been removed.

A small iron bar about 2 feet long that had been used for digging the holes for the posts was driven down into the broken coral until its end was in the water. This bar was used for a ground connection. The rust was scraped off and the surface sandpapered. A stout stranded copper wire was securely fastened to the bar and connection made both to the screw in the base of the electrometer and to the binding-post fastened to the inner case. The little screw-cap earthing-device attached to the inner-case binding-post was screwed in to make contact with the electrometer case as an extra precaution.

The electrometer was tested for leak at the beginning of the first set. With an applied potential of 80 volts there was no leak observed during a period of two minutes. The wire that carried the collectors was now connected to the electrometer and a charge put on the system. The electrometer reading remained constant for about one minute and then fluctuated, at first dropping 2 scale-divisions and then increasing 4. After varying for a minute or so, it settled down to its original value. The observer believed these changes to be due to changing values of the potential gradient and not to leak, since there was no tendency for the reading to remain below the original reading. After this test the collectors were put on about midway between the posts, and readings were started very shortly afterwards. The *Carnegie* had left her anchorage and come out under her own power to within one-half mile of the reef. It had been arranged beforehand that the flag should be raised at the mainmast as soon as observations were commenced on shipboard. The watches used by both parties were made to agree to within two seconds so as to facilitate a comparison of the results. As soon as observations were started on shipboard, readings were taken on shore every 30 seconds for one hour in each sail position. Owing to the roll of the *Carnegie*, it was not possible to take readings exactly on the minute and half minute. Efforts were made on shore, however, to take readings when the prime conductor was horizontal. This variation rarely exceeded three seconds.

The *Carnegie* maneuvered around off the reef at a distance ranging from one-fourth to one-half mile from the shore station. Part of the time she was assisted by the pilot's tug. No observations were taken while the engines were going or when the pilot tug was near the stern. She did not carry sail on the foremast during observations. The boom was as nearly as possible in its regular position over port crutch and in its usual position for a fair wind when the mainsail was raised.

There was bright sunshine throughout the entire observations. The sky had a few light cirrus clouds, and for perhaps 10° up from the horizon there were banks of cumulus clouds especially noticeable on the mountains. The wet-bulb and dry-bulb readings at 16^h05^m on shipboard were 23°.5 and 27°.6 centigrade, which give a relative humidity of 71 per cent. During the afternoon the humidity was probably less.

At the close of the second set of observations the collector system was earthed and the time required to build up the potential was measured. This could not be done accurately because of the varying potential of the air. It was probably more than 75 seconds and less than 110 seconds. The collectors were now removed and another leak-test made for the system. The electroscope reading fluctuated, as at first, but generally increased. The system was now earthed, and it was found that the system charged up by itself in 6 or 7 minutes to the same range as had been observed previously.

SPECIAL REPORTS

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THE HUDSON BAY EXPEDITION, 1914.

By W. J. Peters.

INTRODUCTION AND VESSEL DESCRIPTION.

The Hudson Bay Expedition of 1914 was organized by the Department of Terrestrial Magnetism to secure magnetic observations along the coast of Labrador and the shores of Hudson Bay and Hudson Strait. Aside from expeditions especially organized for the purpose, the only practical means of travel during the summer in these regions is by permission on the few vessels sent in either by the Canadian Government or by the trading companies. The sailings of these vessels are necessarily uncertain, and their destinations or cruises are usually not very favorable for a magnetic exploration of the region.

Therefore, the three-masted gasoline schooner *George B. Cluett* was chartered from the International Grenfell Association for the sum of $5,000 for the season of three months, beginning July 1, 1914. The *George B. Cluett* is a wooden vessel of 210 gross tons (Fig. 7) built in 1911, at Tottenville, New Jersey, for carrying stores and supplies to the hospitals on the Labrador coast and for the purpose of revenue by charter to hunting and fishing or scientific expeditions. Her dimensions are 135 feet over all, 115 feet on water line, 26 feet molded breadth, and 12 feet molded depth. She is equipped with a three-cylinder oil engine of 75 horsepower. The forecastle has accommodation for a crew of 5.

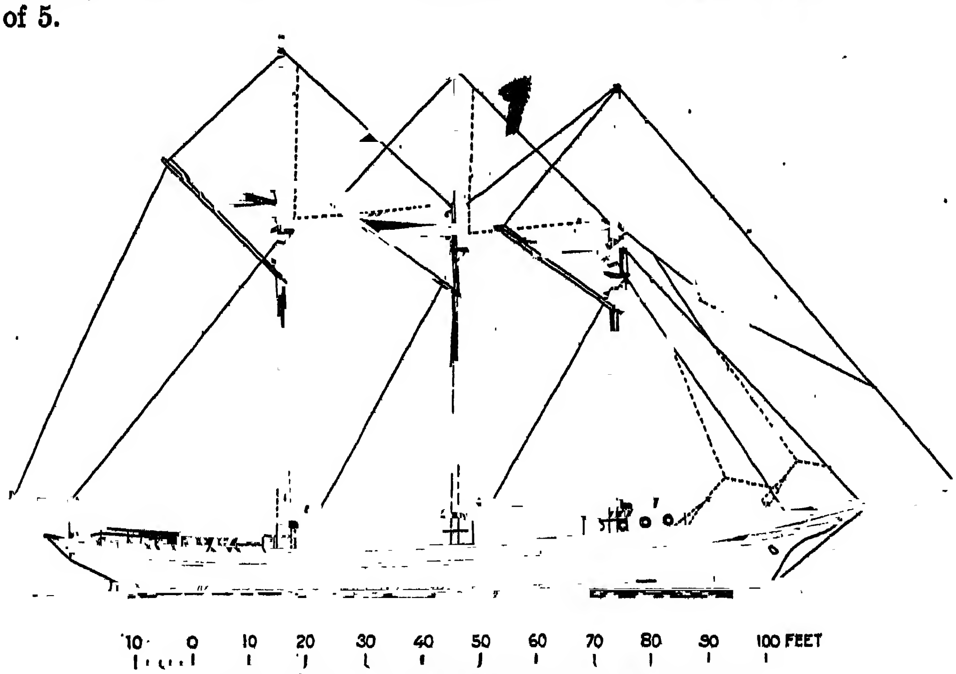

Fig. 7.—Sail Plan of Auxiliary Schooner *George B. Cluett*.

Structural changes or additions to improve the magnetic conditions immediately around the gimbal stand were impractical, in view of the short season and the circumstances attending embarkation. As there was a considerable quantity of movable iron in the iron work of the booms, in the boats, in the engine room, etc., the vessel was always

swung when magnetic observations were made. Uncertainties that might have been introduced by the movable magnetic material were thus eliminated, at least from the harmonic part of the ship's deviation-corrections.

The iron permanently in place included the ordinary fastenings in knees, beams, frames and inner and outer skin (see diagrammatic section of the *Galilee*, Fig. 4, Vol. III, p. 129), water and fuel tanks, engine, hatch-coaming, mastbands, and steel rigging.

CHARTER-PARTY OF THE GEORGE B. CLUETT.

The *George B. Cluett* was placed at the service of the Department of Terrestrial Magnetism at Battle Harbor on July 8, after a few days delay caused by unloading at some earlier port, in accordance with the following charter-party:

It is hereby mutually agreed between the International Grenfell Association, party of the first part, agents of the good ship or vessel called the "George B. Cluett," Burthen per Register 155 tons or thereabouts, H. C. Pickels, master, and the Department of Terrestrial Magnetism of the Carnegie Institution of Washington, party of the second part:

That the said party of the first part shall provide the said ship in tight, staunch, and strong condition, in every way fitted for the voyage, and that said ship shall, at Battle Harbor, Labrador, on July 1, 1914, take on board not exceeding three (3) members of a Research Party of said Department of Terrestrial Magnetism, and shall then proceed with them to Hudson Bay, and stop at any points designated by the chief of said Research Party, and return with the said party to Battle Harbor, Labrador. That the time of said charter shall be three (3) months.

That the party of the first part shall provide said vessel, launch, captain, pilot, special engineer, crew, ship's cook, food for crew and for cabin, including the members of said Research Party, fuel, insurance, charts, and all other necessaries for navigation.

The party of the second part shall pay to the party of the first part for said charter the sum of Five Thousand Dollars ($5,000), of which Two Thousand Five Hundred Dollars ($2,500) shall be paid at the time of signing this agreement, and the balance of Two Thousand Five Hundred Dollars ($2,500) at the termination of said voyage.

That the said Research Party of the party of the second part shall not detain the said vessel in Hudson Bay or Hudson Strait to such date as to endanger detention by ice, and the said vessel shall be brought out of the Hudson Bay and Hudson Strait at such time as shall be fixed by the Captain commanding said vessel, in his discretion, to avoid detention by ice, and the party of the second part shall not be liable in any way for any delay over the charter period caused by detention by ice, or by the act of God, the King's enemies, fire, and all and every other danger and accident of the Seas, Rivers, and navigation during the said voyage.

If, after coming out of Hudson Bay and Hudson Strait on the return voyage, the vessel shall be detained at request of the chief of the Research Party for observations or work along the Atlantic Coast to a period beyond the termination of the charter period of three months, the said party of the second part shall pay Fifty Dollars ($50) per day for each day so detained in excess of the charter period.

Signed at Washington, District of Columbia, U. S. A., this 18th day of June, 1914.

THE INTERNATIONAL GRENFELL ASSOCIATION.

Witnesses:

(Signed) J. J. H. EVANS.
(Signed) FRED G. COLDREN.

(Signed) WILFRED T. GRENFELL, M.D., *Superintendent*.
(Signed) LOUIS A. BAUER, *Director*,
Department of Terrestrial Magnetism,
Carnegie Institution of Washington.

Extraordinary ice conditions along the Labrador coast held the vessel at Battle Harbor until July 30, after which she proceeded to force a way through loose ice along the coast. Anchorages were made usually every day on account of ice conditions or foul weather, but the vessel was frequently underway for several days in succession. The ice in Hudson Strait caused but little delay and Eskimo Cape, on the western shore of Hudson Bay, was reached September 12, 1914. Captain H. C. Pickels, master, decided then, according to the terms of the charter, that the vessel should return at once on account of the approaching end of the season. Anchor was therefore weighed September 15 for the return, and the *George B. Cluett* arrived at Battle Harbor, where the final swings were

made on October 7, 1914. The vessel was returned to her owners on October 8, exactly three months from the date of receiving.

It is a pleasure to recall the most cordial relations with the Grenfell Association, and the hospitality extended by the various members of that association during the protracted wait at Battle Harbor. Doctor Grenfell himself assisted in swinging the *George B. Cluett* by towing with the Grenfell Association's hospital ship, the *Strathcona*, the *George B. Cluett's* engine being temporarily out of commission, an act that was especially appreciated, as his mission work occupied practically all of Doctor Grenfell's time.

METHODS OF WORK AND MAGNETIC INSTRUMENTS USED.

The working conditions encountered on the Hudson Bay Expedition did not permit a close adherence to the methods of work as described for the *Galilee* or *Carnegie* in Volume III (pp. 14–16). The force consisted of but 2 men, the leader and his assistant. The quarters were small and living arrangements restricted the hours of computation. However, the methods of observation of the Department of Terrestrial Magnetism for magnetic elements at sea were followed as closely as the instrumental outfit permitted, and observations were confined to swings because of the impracticability of controlling the location of movable iron.

The character of the coast and the presence of ice restricted the navigational work principally to piloting. Therefore, the log was rarely used, and astronomical observations were made only when the vessel was swung so far out at sea that reliable landmarks for fixing the geographic position were not available.

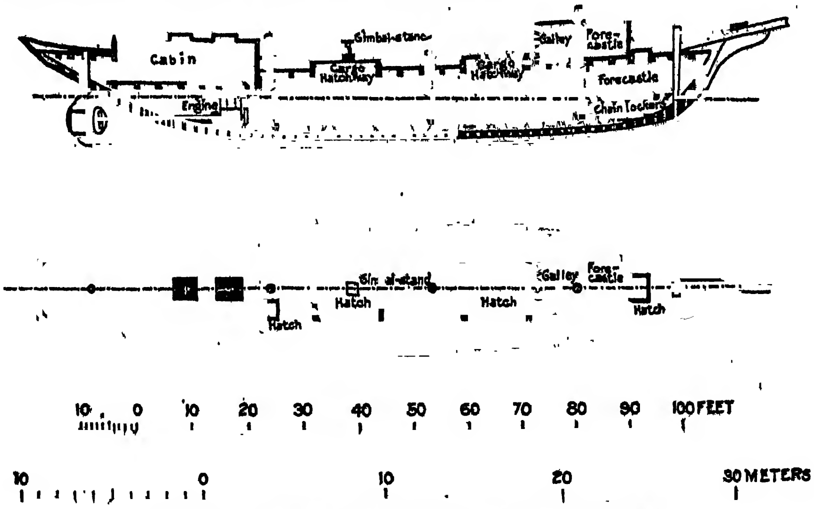

FIG. 8.—Profile and Deck Plan of the *George B. Cluett*.

All magnetic observations were made on board the *George B. Cluett* with instruments mounted temporarily during the observation on a Dover gimbal-stand which was permanently fastened to the hatch of the after cargo hatchway (Fig. 8). Magnetic inclination was obtained with Dover dip-circle 169, occasionally with needles 5 and 6 but more often with intensity needles 7 and 8, and magnetic declinations were determined with deflector 3. Both instruments are described in Volume III (pp. 21–23 and 190–194). Results for the intensity of the Earth's magnetic field were derived mostly from the dip-circle deflection observations with needles 7 and 8, as a trial with deflector 3 had demonstrated the impracticability of using compass deflections at sea in a region of such low horizontal intensity. Another determining factor in this selection was that deflections with dip circle 169 yielded results for two elements, dip

and intensity, from one set of observations, an important advantage, as the sea observations on this expedition did not allow the regular and extensive program of observation. The instrumental outfit was as follows:

I. *For magnetic declination at sea.*—Deflector 3, designed and constructed by the Department of Terrestrial Magnetism, designated in the table and list as D3.

II. *For magnetic inclination and total intensity at sea.*—Sea dip-circle 169 with dip needles 5, 6, 9, and 10 and intensity needles 7, 8, 11, and 12, designated 169, followed by the numbers of dip needles in Roman type and of intensity needles in italicized type, thus 169.5*78* or 169.*78*.

III. *For horizontal intensity at sea.*—Sea deflector 3 with deflecting magnet IXL used as an intensity measuring instrument only during the preparatory swings at Battle Harbor.

IV. *For magnetic declination and horizontal intensity on land.*—Magnetometer 13 complete with tripod, deflection bar, and appurtenances, constructed by the Department of Terrestrial Magnetism.

V. *For magnetic inclination on land.*—Land dip-circle 4655, provided with dip needles 1X, 2X, and 7 and 8 of dip circle 201. The circle is by A. W. Dover, and the designation is 4655.(12).

VI. *Miscellaneous equipment.*—(1) One small theodolite; (2) pocket chronometers 244, 256 of A. Kittel; (3) Elgin watches 107, 113, and 116; (4) pocket compasses Nos. 17 and 19; (5) extra thermometers; (6) steel tapes; (7) field-glasses; (8) kodaks; (9) tool-kit; (10) tents; (11) tripods; (12) gimbal-stand; and (13) sounding machine.

SHIP CONSTANTS AND DEVIATION-COEFFICIENTS.

As all the magnetic observations were made on the *George B. Cluett* during swings, the determination of harmonic coefficients is not necessary for obtaining final results and was made merely for comparison and record. Unusually large fluctuations in these coefficients are ascribed partly to unavoidable changes in the distribution of iron within effective distance of the gimbal-stand, partly to the high magnetic inclination and the low horizontal intensity prevailing in the region traversed by the expedition.

Deviation formulæ for declination, inclination, horizontal intensity, and vertical intensity, given in Volume III (pp. 78–80), are repeated here for convenience of reference.

DEVIATION FORMULAE.

Let the so-called deviation-coefficients for the magnetic elements, declination (D), inclination (I), horizontal intensity (H), and vertical intensity (Z), be

$$\begin{array}{ll} \text{For } D: & A_d,\ B_d,\ C_d,\ D_d,\ E_d \\ \text{For } I: & A_i,\ B_i,\ C_i,\ D_i,\ E_i \\ \text{For } H: & A_h,\ B_h,\ C_h,\ D_h,\ E_h \\ \text{For } Z: & A_z,\ B_z,\ C_z \end{array}$$

Then the deviation formulæ for D, I, H, and Z, after various transformations and approximations, may be written as follows:

$$\begin{aligned} D'-D &= \delta D = A_d + B_d \sin \zeta + C_d \cos \zeta + D_d \sin 2\zeta + E_d \cos 2\zeta \\ I'-I &= \delta I = A_i + B_i \cos \zeta + C_i \sin \zeta + D_i \cos 2\zeta + E_i \sin 2\zeta \\ H'-H &= \delta H = A_h + B_h \cos \zeta + C_h \sin \zeta + D_h \cos 2\zeta + E_h \sin 2\zeta \\ Z'-Z &= \delta Z = A_z + B_z \cos \zeta + C_z \sin \zeta \end{aligned}$$

D', I', H', Z' are, respectively, the observed ship values of the declination, inclination, horizontal intensity, and vertical intensity; D, I, H, Z are the true, or undisturbed, values those which would be observed if the ship were wholly nonmagnetic.

The deviation-correction is the quantity to be applied to the magnetic element observed aboard ship to obtain the true or undisturbed value. It is of opposite sign to the deviation; thus, *e. g.*, $D = D' - \delta D$; etc.

Since the deviations were small on the vessels considered, ζ may be assumed to be the ship's magnetic course as recorded, or as the indicated magnetic azimuth of the ship's head, measured continuously from the magnetic north through east.

Let $\lambda = 1 + H'/H$, $\mu = Z'/Z$, and let the so-called "exact deviation-coefficients" be indicated by primes, *e. g.*, A'_d, B'_d, etc.; then the relations existing between the parameters and the deviation-coefficients are:

FOR DECLINATION

$$\lambda = 1 + \frac{1}{2}(a+e)$$

$$A'_d = \sin A_d = \frac{1}{\lambda}\left(\frac{d-b}{2}\right)$$

$$B'_d = \sin B_d = \frac{1}{\lambda}\left(c \tan I + \frac{P}{H}\right)$$

$$C'_d = \sin C_d = \frac{1}{\lambda}\left(f \tan I + \frac{Q}{H}\right)$$

$$D'_d = \sin D_d = \frac{1}{\lambda}\left(\frac{a-e}{2}\right)$$

$$E'_d = \sin E_d = \frac{1}{\lambda}\left(\frac{d+b}{2}\right)$$

FOR INCLINATION

$$A'_i = \sin A_i = \frac{1}{2}(\lambda - \mu) \sin 2I = \frac{1}{2}\left(\lambda - k - 1 - \frac{R}{Z}\right) \sin 2I$$

$$B'_i = \sin B_i = \frac{1}{2}(\lambda B'_d - g \cot I) \sin 2I = \frac{1}{2}(c-g) - \frac{1}{2}(c+g) \cos 2I + \frac{1}{2}\frac{P}{H} \sin 2I$$

$$C'_i = \sin C_i = \frac{1}{2}(h \cot I - \lambda C'_d) \sin 2I = \frac{1}{2}(h-f) + \frac{1}{2}(h+f) \cos 2I - \frac{1}{2}\frac{Q}{H} \sin 2I$$

$$D'_i = \sin D_i = +\frac{1}{2}\lambda D'_d \sin 2I = \frac{1}{2}\left(\frac{a-e}{2}\right) \sin 2I$$

$$E'_i = \sin E_i = -\frac{1}{2}\lambda E'_d \sin 2I = -\frac{1}{2}\left(\frac{d+b}{2}\right) \sin 2I$$

FOR HORIZONTAL INTENSITY

$$A_h = \frac{H}{2}(a+e) = H\,(\lambda - 1)$$

$$B_h = cH \tan I + P = \lambda H\, B'_d = \lambda H \sin B_d$$

$$C_h = -fH \tan I - Q = -\lambda H\, C'_d = -\lambda H \sin C_d$$

$$D_h = \frac{H}{2}(a-e) = \lambda H\, D'_d = \lambda H \sin D_d$$

$$E_h = -\frac{H}{2}(d+b) = -\lambda H\, E'_d = -\lambda H \sin E_d$$

FOR VERTICAL INTENSITY

$$A_z = kZ + R = Z\,(\mu - 1)$$

$$B_z = gZ \cot I$$

$$C_z = -hZ \cot I$$

$$\mu = k + 1 + \frac{R}{Z}$$

The parameters $a, b, c, d, e, f, g, h, k$ depend on the amount, arrangement, and inductive capacity of the soft iron of the ship. P, Q, R are parameters depending on the amount, arrangement, and permanent or subpermanent magnetism of the hard iron of the ship.

The deviation coefficients of the *George B. Cluett* are given in Tables 36 and 37. They all apply to the position of the Dover dip-circle stand as shown in Figure 8, but it should be noted that although the two instruments, deflector 3 and dip circle 169, are mounted on the same stand, the center of the dip-circle needle was about 22 cm. higher than the card of deflector 3, because of the different methods of mounting the two instruments on the gimbal-stand.

TABLE 36.—*Declination Deviation-Coefficients and Details Regarding Swings of the George B. Cluett, 1914.*

No. of swing	Place	Lat. N.	Long. E. of Gr.	Date	Approximate magnetic elements: D	I	H	Declination: A_d	B_d	C_d	D_d	E_d	P. E.	Head-ings	Com-pass
		°	°	1914	°	°	c. g. s.	°	°	°	°	°	°	p s	
1	Battle Harbor.......	52.3	304.4	Jul 11	−35.6	+76.2	0.135	....	....	....	....	....	....	....	....
2	Battle Harbor.......	52.3	304.4	Jul 17	−35.6	+76.2	.135	....	....	....	....	....	....	....	....
3	Battle Harbor.......	52.3	304.4	Jul 22	−35.6	+76.2	.135	....	....	....	....	....	....	....	....
4	At sea.............	58.2	299.2	Aug 15	−43.7	+80.1	.106	−0.24	−0.98	−3.47	+0.72	−0.46	±0.17	8 8	D3
5	At sea.............	61.3	292.6	Aug 24	−49.6	+82.4	.079	−0.24	+0.69	−2.77	+0.44	−0.56	±1.03	8 ..	D3
6	At sea.............	62.0	291.5	Aug 25	−50.1	+83.1	.074	−0.24	−1.92	−4.96	−0.05	−1.36	±0.25	.. 8	D3
7	At sea.............	62.4	288.2	Aug 30	−50.0	+83.8	.065	....	....	....	....	....	....	....	....
8	At sea.............	62.7	284.5	Aug 31	−49.1	+84.9	.055	−0.24	+0.45	−3.34	+1.21	+0.30	±0.25	6 ..	D3
9	At sea.............	57.6	277.6	Sep 9	−20.2	+83.9	.060	−0.24	+2.15	−4.37	−0.01	−0.05	±0.25	.. 8	D3
10	At sea.............	58.5	274.4	Sep 10	−14.9	+84.6	.060	....	....	....	....	....	....	....	....
11	At sea.............	60.2	270.2	Sep 11	−10.4	+85.4	.046	−0.24	+2.40	−8.42	+2.06	−0.58	±0.76	8 ..	D3
12	At sea.............	62.0	277.4	Sep 18	−35.0	+85.8	.046	....	....	....	....	....	....	....	....
13	At sea.............	61.3	293.3	Sep 27	−50.0	+82.7	.076	....	....	....	....	....	....	....	....
14	At sea.............	58.5	299.0	Sep 29	−44.5	+79.9	.103	....	....	....	....	....	....	....	....
15	Battle Harbor.......	52.3	304.4	Oct 7	−35.6	+76.2	.134	−0.24	−0.82	−2.03	+0.57	+0.40	±0.18	8 8	D3
16	Battle Harbor.......	52.3	304.4	Oct 7	−35.6	+76.2	.134	....	....	....	....	....	....	....	....

TABLE 37.—*Inclination and Horizontal-Intensity[1] Deviation-Coefficients and Details Regarding Swings of the George B. Cluett, 1914.*

No. of swing	Inclination: A_i	B_i	C_i	D_i	E_i	P. E.	Horizontal intensity: A_h	B_h	C_h	D_h	E_h	P. E.	Instru-ment	Head ings	Swing by	Remarks: Roll	Sea	Wea-ther
	°	°	°	°	°	°								p s		°		
1	−0.68	−0.56	+0.11	−0.01	−0.10	±0.05	−3	+54	−10	+ 4	+11	± 6	169.578	8 8	Engine........	0	S	f
2	....	....	....	....	....	....	} −3	+35	−26	+15	+ 4	±26	D3IXL[2]	{8 ..	Tug..........	0	S	c
3	....	....	....	....	....	....								.. 8	Tug..........	0	S	c
4	....	....	....	....	....	....	....	....	....	....	....	....	....	....	Engine........	4	S	m
5	....	....	....	....	....	....	....	....	....	....	....	....	....	....	Do........	0	S	b
6	....	....	....	....	....	....	....	....	....	....	....	....	....	....	Do........	0	S	b
7	−0.31	−0.50	−0.10	−0.07	−0.01	±0.09	−2	+50	+23	+ 2	+ 6	±12	169.78	8 8	Do........	0	S	bc
8	....	....	....	....	....	....	....	....	....	....	....	....	....	....	Do........	0	S	b
9	....	....	....	....	....	....	....	....	....	....	....	....	....	....	Do........	3	S	b
10	−0.27	−0.50	+0.40	+0.05	−0.12	±0.13	−2	+62	−41	− 3	+ 1	± 9	169.78	.. 8	Do........	20	MR	oc
11	....	....	....	....	....	....	....	....	....	....	....	....	....	....	Do........	6	M	b
12	−0.22	−0.66	−0.14	−0.01	−0.10	±0.08	−1	+66	+18	+ 8	+ 9	± 9	169.78	8 ..	Do........	9	M	c
13	−0.37	−0.57	−0.07	+0.07	+0.03	±0.06	−2	+57	+ 2	− 1	+ 1	± 8	169.78	.. 8	Do........	13	R	oo
14	−0.51	−0.38	−0.19	+0.04	+0.08	±0.05	−8	+38	+17	− 4	− 4	± 6	169.78	7 ..	Sail..........	6	S	oo
15	....	....	....	....	....	....	} −3	+24	−16	− 4	+ 4	±10	169.678	8 8	Engine........	{9	M	c
16	−0.68	−0.18	+0.18	0.00	−0.10	±0.06										9	M	c

[1] Intensity deviation-coefficients and probable errors are expressed in units of the fourth decimal c. g. s

[2] Distance 2, deflector 3, was used on July 17 and distance 4 on July 22.

Volume III (p. 91) gives for the chief vessels which have been engaged in ocean magnetic work the 12 fundamental deviation-constants (or combinations of them) that represent the induced and permanent magnetic forces aboard ship. It is reproduced here and extended to include the *George B. Cluett*. The data for the first four vessels have been taken from Bidlingmaier's article, page 486 of the 1905 edition of Neumayer's "Anleitungen"; sm. in the table means a small value. The data for the *Discovery*, 1904, are taken from pages 148–149 of the volume on "Physical Observations of the National Antarctic Expedition, 1901–1904." A'_d and E'_d were assumed to be zero.

The values given in Table 38 are the mean parameters when they can be determined independently by each instrument or by separate data for each magnetic element. The extraordinarily large values of f, h, and R for the *George B. Cluett* are probably the effects of the iron water tanks, the engine-room accessories, and steel rigging.

TABLE 38.—*Deviation-Constants for the Chief Vessels which have been engaged in Ocean Magnetic Work.*

[All quantities are expressed in units of the third decimal except λ. P, Q, R are expressed in units of the third decimal C. G. S.]

Constant	Erebus, 1839 to 1842	Challenger, 1873 to 1876	Gazelle, 1874 to 1876	Gauss, 1901 to 1903	Dis-covery, 1904	Galilee, 1905–1908 Stand. comp.	Galilee, 1905–1908 Sea deflector	Galilee, 1905–1908 Sea dip-circle	Galilee, 1905–1908 Mean	George B. Cluett, 1914
$\lambda = 1 + \frac{a+e}{2}$	0.991	0.999	0.980	1.003	0.973	....	1.000	0.999	1.000	0.998
$A'_d = \frac{1}{\lambda}\,\frac{d-b}{2}$	0	+ 2	+ 6	+ 5	0	0	+1	....	0	− 4
$D'_d = \frac{1}{\lambda}\,\frac{a-e}{2}$	+ 7	+ 6	+11	+21	+19	+2	−2	+1	0	+ 5
$E'_d = \frac{1}{\lambda}\,\frac{d+b}{2}$	sm.	0	− 2	0	0	−1	+1	0	0	− 2
g	+27	0	+13	− 5	....	....	....	−1	−1	0
h	sm.	0	+ 9	0	....	....	....	−6	−6	+ 451
c	+26	+ 8	+21	−12	+ 3	0	+4	−3	0	− 14
f	sm.	0	− 7	+ 1	0	0	0	+2	+1	+1148
k	+ 8	−33	−21	−13	−22	....	....	−8	−8	− 48
P	sm.	+13	+ 8	+ 2	+ 3	0	0	0	0	+ 9
Q	sm.	0	− 3	0	0	0	0	−3	−1	+ 95
R	sm.	−40	− 2	− 2	+ 4	....	....	−1	−1	+ 80

The value of the coefficient μ which represents the mean amount of vertical force on board ship as compared with the Earth's vertical force was $\mu = 1.049$ for the *George B. Cluett.*

OCEAN MAGNETIC OBSERVATIONS ON THE GEORGE B. CLUETT, 1914.

EXPLANATORY REMARKS.

As nearly as possible the same conventions have been followed as in volumes I, II, and III.

Stations.—The stations are numbered consecutively in the first column.

Geographic positions.—The second and third columns contain, respectively, the latitude and longitude (counted east from Greenwich), expressed in degrees and minutes, to the nearest minute of arc. The latitudes and longitudes for the points of observation at sea were determined by Sun altitudes usually both at the beginning and at the end of the swing. In general they may be regarded as correct within 5 or 6 nautical miles.

Date.—The date on which the magnetic observations were made is recorded in the fourth column. The following abbreviations have been adopted for the months of the year: Jan, Feb, Mar, Apr, May, Jun, Jul, Aug, Sep, Oct, Nov, Dec. The year is indicated at the head of the column.

Magnetic elements.—The values of the magnetic elements (declination, inclination, and horizontal intensity) will be found in the next columns, preceded in each case by the local mean time (L. M. T.) of observation, expressed to nearest 0.1 of an hour. Where numerous observations were made during a certain interval, as during a vessel's swing, local mean times are recorded for the beginning and for the ending of the swing. The local mean times are given according to civil reckoning and are counted from midnight as zero hour continuously through 24 hours; 16^h, for example, means 4 o'clock p. m.

The ocean values of magnetic declination and inclination are given in degrees and minutes, to the nearest minute of arc. No claim, however, is made that they are correct to a minute of arc. In general the error in the tabulated value is about $5'$ to $10'$; in some

cases the error may be 15′ to 20′, depending on the severity of the conditions encountered during the observations. It was thought best to retain the original quantities resulting from the computations until the various corrections, mentioned below, had been applied. The error of a harbor result, usually depending upon extensive observations during the swing of the vessel, is generally not over 5′, and may be less. The letters *E* and *W* serve to indicate whether the magnetic declination is east or west of north. The letters *N* and *S* show whether the north-seeking end of the magnetic needle points below the horizon, as it does in the northern magnetic hemisphere, or above, as it does in the southern magnetic hemisphere.

The ocean values of horizontal intensity are tabulated to the fourth decimal of the C. G. S. unit of magnetic field-intensity. In magnetic-survey work on land the fourth decimal is often uncertain by one or more units, and in ocean work, especially in this region, the error may be several units in the third decimal place. It is thus to be understood that no claim is made for the correctness of the last figure; it has been retained here primarily in order that when all reductions to common epoch have been applied on account of the various magnetic variations, the error (due purely to computation) will be kept down to the desired limit.

The question whether to give values of the horizontal intensity exclusively, or values of total intensity, was decided in the previous volumes, for reasons there stated, in favor of the former.

The instruments used are shown in the columns "Compass" and "Dip circle." The designations of the various instruments employed will be found stated on page 294. The term "Compass" also includes the "Sea deflector," with which declinations were observed (see Vol. III, pp. 190–195). The term "Dip circle" likewise includes the "Sea dip-circle" when used for determination of the total intensity from which the horizontal intensity is derived. The designation 169.5*78*, for example, means that dip circle 169 was used, the inclination being observed with regular dip needle 5, and with deflected needle 7, and that the total intensity was observed with the same instrument by the deflection method, using the intensity needles 7 and 8 (the ones italicized). Invariably the intensity needles are italicized and are given last. The higher number of the two intensity needles always designates the chief intensity needle (the deflecting and the loaded needle). The columns of "Remarks" contain:

a. Roll. This column records the average *full* angle through which the ship rolled, from side to side; it is double the recorded clinometer-readings.

b. Sea. The state of the sea is indicated by the following symbols:

B.—Broken or irregular sea.	*H.*—Heavy sea.	*R.*—Rough sea.
C.—Chopping, short or cross sea.	*L.*—Long, rolling sea.	*S.*—Smooth sea.
G.—Ground swell.	*M.*—Moderate sea, or swell.	*T.*—Tide rips.

When different observers record the state of the sea independently, it frequently happens that their estimates or designations vary. In many of these cases one particular letter was selected, after a careful consideration of all the symbols given by the various observers, supplemented by the recorded ship's roll, and by other notes.

c. Weather. The symbols denoting the state of weather at the time are those in general use:

b.—Clear, blue sky.	*l.*—Lightning.	*s.*—Snow.
c.—Clouds.	*m.*—Misty.	*t.*—Thunder.
d.—Drizzling or light rain.	*o.*—Overcast.	*u.*—Ugly appearances, threatening weather.
f.—Fog or foggy weather.	*p.*—Passing showers.	*v.*—Variable weather.
g.—Gloomy, dark, stormy.	*q.*—Squally.	*w.*—Wet or heavy dew.
h.—Hail.	*r.*—Rain.	*z.*—Hazy weather.

Weights.—The figures given in the column marked "Wt." are the weights assigned the results on the following scale, which expresses, in a general way, the conditions as to sea, weather, instruments, and experience under which the observations were made: 1, severe or adverse conditions; 2, medium conditions; and 3, favorable conditions.

Magnetic standards.—As stated in Volume IV (pp. 9–18), the Department's extensive intercomparisons of magnetic instruments at Washington, in the field, and at magnetic observatories in all parts of the Earth have made it possible to refer its data to provisional "International Magnetic Standards." These standards, designated I. M. S., have been adopted for the results of this expedition. The instruments used as standards by the Department were as follows: In declination, C. I. W. magnetometer 3 with correction on I. M. S. of $-0'.1$ to observed values; in horizontal intensity, C. I. W. magnetometer 3 with zero correction on I. M. S. to observed values; in inclination, earth inductor 48, made by Schulze, with zero correction on I. M. S. to observed values.

Instrument corrections.—The corrections and constants of the magnetometer, dip circles, and deflector used, on the adopted standards, were determined at Washington before and after use of the instruments on the expedition and at the land stations at Battle Harbor. The resulting constants have all been reduced on the basis of International Magnetic Standards as above defined. The adopted corrections for the period of the expedition are as follows:

Magnetometer 13.—In declination, $-0'.5$ and $-0.00099H$ in horizontal intensity.

Dip circle 169.—In declination, $-1'.6$ when mark was read by telescope, and $-3'.8$ when mark was read by peep-sights. In inclination, for values from $+71°$ to $+87°$: needle 5, $-0'.2$; needle 6, $-1'.0$; needle 7, deflected by needle 8, at the short distance $+4'.4$, and at the long distance $+4'.2$. The total-intensity constants for needle-pair 7 and 8 were at the short distance $\log C_t = 9.68338$ and $\log C_d = 9.49153$; $\log C_d$ for the long distance $= 9.34509$; all of these apply for the temperature 20° centigrade, the effect of one degree change in temperature being 0.00010.

Dip circle 4655.—In declination, $-1'.1$, this applying for compass attachment of circle 201, which was used with circle 4655. In inclination, for values from $+71°$ to $+87°$: needle 1X, $+0'.5$; needle 2X, $-0'.6$; needle 7 deflected by needle 8 of circle 201, $-1'.1$. In intensity the logarithm of the total-intensity constant for needle-pair 7 and 8 of 201 was 9.56407.

(For more detailed information regarding the instruments, methods, and corrections reference may be made to the descriptions given in volumes I, II, III, and IV.)

FINAL RESULTS OF OCEAN MAGNETIC OBSERVATIONS ON THE GEORGE B. CLUETT
1914 CRUISE INTO HUDSON BAY.

Station	Lat.	Long. East of Gr.	Date	Declination L. M. T.	Declination Value	Declination Wt.	Inclination L. M. T.	Inclination Value	Inclination Wt.	Hor. intensity L. M. T.	Hor. intensity Value	Hor. intensity Wt.	Instruments Compass	Instruments Dip circle	Remarks Roll	Remarks Sea	Remarks Weather
	° ′	° ′	1914	h h	° ′		h h	° ′		h h	c.g.s.				°		
1	52 18 N	304 22	Jul 11	....	....	....	13.9 to 16.7	76 13 N	....	13.9 to 15.2	0.1349	2	......	169.578	0	S	f
			Jul 17	....	....	....	....	....	....	4.8 to 7.1	.1355	2	D3	....	0	S	f
			Jul 22	....	....	....	....	....	....	5.5 to 7.5	.1363	2	D3	....	0	S	f
2	58 15 N	299 11	Aug 15	5.9 to 8.1	43 44 W	2	....	....	....	....	....	....	D3	....	4	S	m
3	61 19 N	292 39	Aug 24	18.4 to 18.9	49 34 W	2	....	....	....	....	....	....	D3	....	0	S	b
4	61 59 N	291 28	Aug 25	18.3 to 18.6	50 04 W	2	....	....	....	....	....	....	D3	....	0	S	b
5	62 24 N	288 12	Aug 30	....	....	....	8.9 to 11.6	83 51 N	....	10.0 to 11.6	.0647	2	......	169.578	0	S	bc
6	62 40 N	284 32	Aug 31	16.9 to 17.3	49 07 W	2	....	....	....	....	....	....	D3	....	0	S	b
7	57 39 N	277 33	Sep 9	6.5 to 6.9	20 14 W	2	....	....	....	....	....	....	D3	....	3	S	b
8	58 29 N	274 24	Sep 10	....	....	....	16.2 to 18.3	84 36 N	....	16.2 to 18.3	.0604	2	......	169.78	20	MR	oc
9	60 14 N	270 12	Sep 11	16.7 to 17.1	10 24 W	2	....	....	....	....	....	....	D3	....	6	M	b
10	62 02 N	277 27	Sep 18	....	....	....	15.1 to 16.5	85 46 N	....	15.1 to 16.5	.0463	3	......	169.78	9	M	c
11	61 18 N	293 19	Sep 27	....	....	....	10.4 to 11.6	82 40 N	2	10.4 to 11.6	.0764	2	......	169.78	13	R	oo
12	58 31 N	298 59	Sep 29	....	....	....	15.2 to 16.3	79 54 N	2	15.2 to 16.3	.1031	....	......	169.78	6	S	co
13[1]	52 18 N	304 22	Oct 7	14.6 to 15.5	35 33 W	3	14.3 to 18.6	76 12 N	1	14.3 to 16.5	.1343	2	D3	169.78	9	M	c

[1] Values from 2 swings.

LAND MAGNETIC OBSERVATIONS.

The following results of land magnetic observations made in the course of the expedition are extracted from Volume IV (pp. 69–70), using the same conventions as in that volume, to which reference should be made if fuller information is desired. When the number of an instrument in the magnetometer column is italicized it means that a dip circle was used to get the declination and horizontal intensity, the former by means of the compass attachment, and the latter by means of the total-intensity method.

RESULTS OF LAND OBSERVATIONS ON THE HUDSON BAY EXPEDITION, 1914.

NORTH AMERICA.

CANADA.

Station	Latitude	Long. East of Gr.	Date	Declination Local Mean Time	Declination Value	Inclination L. M. T.	Inclination Value	Hor. intensity L. M. T.	Hor. intensity Value	Instruments Mag'r	Instruments Dip Circle	Obs'r
	° ′	° ′		h h h	° ′	h h	° ′	h h	c. g. s.			
Coats Island	62 37.2 N	277 47	Sep 19, '14	12.7,14.1	39 33.6 W	13.4	86 29.4 N	13.4	0.*05731*	*4655*	4655.(12)	P&B
Erik Cove	62 33.2 N	282 35	Sep 1, 14	5.6	42 38.4 W	17.8	84 35.0 N	18.4	*.05830*	*4655*	4655.(12)	DWB
Ashe Inlet, *A*	62 32.8 N	289 25	Aug 27, 14	10.0,13.1	52 02.6 W	14.2	83 40.5 N	11.6,12.6	.06698	13	4655.(12)	P&B
Ashe Inlet, *B*	62 32.8 N	289 25	Aug 27, 14	9.6	51 10.7 W	11.0	83 45.6 N	11.0	*.06583*	*4655*	4655.(12)	WJP
Eskimo Point	61 09.8 N	266 08	Sep 13, 14	9.4,11.9	5 19.8 E	13.0	85 57.8 N	10.0,11.2	.04480	13	4655.(12)	P&B
			Sep 13, 14	....	....	14.6	85 56.5 N	14.5	*.04489*	*169*	169.567	P&B
Smith Island	60 44.2 N	281 21	Sep 3, 14	11.9,13.1	38 20.7 W	15.5	84 37.8 N	12.5,13.5	.05728	13	4655.(12)	DWB
			Sep 3, 14	....	....	....	....	15.5	*.05734*	*4655*	....	DWB
Mistake Bay	59 12.6 N	281 49	Sep 6, 14	8.8,10.7	33 35.7 W	11.8	83 57.9 N	8.9,10.1	.06448	13	4655.(12)	P&B
			Sep 6, 14	14.4	33 47.4 W	16.0	83 58.8 N	16.0	*.06385*	*169*	169.7	P&B
Sydney	46 08.8 N	299 48	Nov 11, 14	14.3,15.9	25 55.2 W	16.8	74 12.1 N	14.8,15.5	.15644	13	169.56	P&B
			Nov 11, 14	16.3	25 48.5 W	....	....	....	....	*169*	....	P&B

NEWFOUNDLAND (INCLUDING LABRADOR COAST).

Station	Latitude	Long. East of Gr.	Date	Declination Local Mean Time	Declination Value	Inclination L. M. T.	Inclination Value	Hor. intensity L. M. T.	Hor. intensity Value	Instruments Mag'r	Instruments Dip Circle	Obs'r
	° ′	° ′		h h h	° ′	h h	° ′	h h	c. g. s.			
Port Burwell, *A*	60 24.8 N	295 08	Aug 21, '14	14.2	45 54.4 W	....	....	....	....	*4655*	....	P&B
			Aug 22, 14	9.2	46 17.1 W	10.7	82 02.0 N	11.9,13.4	0.08314	13	4655.(12)	P&B
			Aug 22, 14	10.1	46 13.8 W	....	....	....	....	*4655*	....	P&B
Port Burwell, *B*	60 24.8 N	295 08	Aug 21, 14	4.0 to 9.3 (dv)	41 31.0 W	15.6	81 48.8 N	12.6,13.7	.08622	13	4655.(12)	P&B
			Aug 21, 14	15.0	41 22.9 W	....	....	....	....	*4655*	....	P&B
Sangmijok	59 59.0 N	295 48	Aug 19, 14	....	....	15.5	81 39.2 N	15.6	*.08636*	*4655*	4655.(12)	P&B
Hopedale	55 27.1 N	299 48	Aug 9, 14	5.8	38 42.2 W	6.8	78 47.4 N	6.8	*.11370*	*4655*	4655.(12)	P&B
Gready*	53 48.2 N	303 35	Aug 4, 14	12.6,13.0	36 42.3 W	14.9	76 49 N	15.3	*.1352*	*4655*	4655.(12)	P&B
Domino	53 28.4 N	304 14	Aug 2, 14	16.8	46 05.6 W	15.6	79 51.4 N	17.5	.10481	13	4655.(12)	P&B
Boulter Rock, *A*	53 06.2 N	304 14	Jul 31, 14	18.0	38 16 W	....	....	....	....	[1]3578	....	WJP
Boulter Rock, *B*	53 06.2 N	304 14	Jul 31, 14	....	....	18.1	76 44.2 N	18.1	*.13106*	*4655*	4655.(12)	DWB
Gull Rocks, *A*	52 18.7 N	304 20	Jul 18, 14	12.0	36 17.4 W	12.9	76 18.8 N	12.9	*.13451*	*4655*	4655.(12)	P&B
Gull Rocks, *B*	52 18.7 N	304 20	Oct 15, 14	13.9,14.4	36 09.8 W	....	....	....	....	*169*	....	P&B
Green Island	52 17.8 N	304 20	Oct 15, 14	10.7,12.0	35 38.8 W	11.3	76 04.6 N	11.3	*.13719*	*169*	169.567	WJP
Great Island	52 17.4 N	304 24	Oct 17, 14	9.3,11.0	37 23.4 W	10.1	76 19.9 N	10.2	*.13485*	*169*	169.567	WJP
Battle Harbor, *C*	52 16.4 N	304 25	Jun 30, 14	19.0,19.2	34 50.6 W	....	....	....	....	13	....	P&B
			Jul 1, 14	5.6, 6.1	34 53.4 W	....	....	9.1,10.7	.13542	13	....	P&B
			Jul 2, 14	9.9	34 49.5 W	15.1	76 07.8 N	15.0	*.13544*	*169*	169.567	P&B
			Jul 3, 14	....	....	9.6,11.3	76 10.7 N	9.3,11.1	*.13480*	*169*	169.567	P&B
			Jul 3, 14	....	....	14.9,16.7	76 07.4 N	14.9,16.7	*.13537*	*4655*	4655.(127)	P&B
			Jul 7, 14	10.6	34 54.0 W	9.5	76 09.7 N	9.5	*.13491*	*4655*	4655.(127)	P&B
			Oct 9, 14	7.5 to 10.0 (5)	34 53.2 W	....	....	....	....	13	....	P&B
			Oct 9, 14	15.4,15.8,16.6	34 56.2 W	....	....	....	....	13	....	P&B
			Oct 10, 14	7.5, 7.7	34 58.8 W	....	....	....	....	13	....	P&B
			Oct 13, 14	14.8	34 57.0 W	....	....	....	....	*4655*	....	P&B
			Oct 14, 14	15.0	34 58.9 W	16.2	76 08.3 N	16.0	*.13532*	*4655*	4655.(127)	P&B
			Oct 16, 14	9.5	34 52.7 W	10.8	76 09.2 N	10.8	*.13457*	*4655*	4655.(127)	P&B
			Oct 19, 14	14.0	34 52.9 W	15.0	76 08.8 N	15.0	*.13477*	*4655*	4655.(127)	P&B
			Oct 20, 14	7.1, 7.4, 7.8	34 51.2 W	10.1,11.8	76 10.5 N	10.0,11.8	*.13462*	*169*	169.567	P&B
			Oct 20, 14	....	....	14.9	76 06.8 N	14.9	*.13555*	*169*	169.567	P&B
Battle Harbor, *D*	52 16.4 N	304 25	Jul 1, 14	....	....	....	....	14.4,15.8	.13552	13	....	P&B
			Jul 2, 14	9.9	34 52.0 W	15.1	76 06.8 N	15.1	*.13534*	*4655*	4655.(127)	P&B
			Jul 3, 14	7.1	34 48.8 W	9.4,11.4	76 11.1 N	9.4,11.4	*.13489*	*4655*	4655.(127)	P&B
			Jul 3, 14	....	....	15.0,16.6	76 09.2 N	15.1,16.7	*.13518*	*169*	169.567	P&B
			Jul 7, 11	10.7	34 57.8 W	9.6	76 11.3 N	9.6	*.13508*	*169*	169.567	P&B
			Oct 14, 14	15.0	35 04.6 W	16.2	76 08.5 N	16.2	*.13503*	*169*	169.567	P&B
			Oct 16, 14	9.6	34 51.3 W	10.8	76 09.3 N	10.8	*.13478*	*169*	169.567	P&B
			Oct 19, 14	14.0	34 56.0 W	15.0	76 11.3 N	15.0	*.13459*	*169*	169.567	P&B
			Oct 20, 14	7.1, 7.4, 7.8	34 47.3 W	10.1,11.8	76 10.3 N	10.0,11.8	*.13494*	*4655*	4655.(127)	P&B
			Oct 20, 14	....	....	14.9	76 08.6 N	14.9	*.13513*	*4655*	4655.(127)	P&B
Battle Harbor, *E*	52 16.4 N	304 25	Oct 23, 14	14.5	34 23.5 W	15.0	76 10.3 N	15.0	*.13488*	*4655*	4655.(7)	DWB
Battle Harbor, *F**	52 16.4 N	304 25	Oct 23, 14	14.5	32 52.0 W	15.0	76 37.6 N	15.0	*.13077*	*169*	169.7	WJP
Battle Harbor, *G*	52 16.4 N	304 25	Oct 23, 14	15.7	34 43.6 W	16.1	76 09.6 N	16.1	*.13498*	*4655*	4655.(7)	DWB
Battle Harbor, *H*	52 16.4 N	304 25	Oct 23, 14	15.7	34 40.4 W	16.1	76 11.0 N	16.1	*.13459*	*169*	169.7	WJP
Battle Harbor, *I*	52 16.1 N	304 25	Oct 26, 14	9.5	36 10.6 W	10.0	76 09.9 N	10.0	*.13448*	*169*	169.7	WJP
Battle Harbor, *J*	52 16.1 N	304 25	Oct 26, 14	11.2	36 07.3 W	12.2	76 21.0 N	12.2	*.13364*	*169*	169.7	WJP
Battle Harbor, *K*	52 16.1 N	304 25	Oct 26, 14	9.5	38 07.1 W	10.0	76 00.3 N	10.0	*.13882*	*4655*	4655.(7)	DWB
Battle Harbor, *L**	52 16.1 N	304 25	Oct 26, 14	10.6	34 50.7 W	13.0	77 00.0 N	....	....	*4655*	169.7	P&B
			Oct 26, 14	....	....	....	....	13.0	*.12768*	*169*	....	P&B
Battle Harbor, *M*	52 15.4 N	304 22	Oct 24, 14	13.2	35 48.0 W	13.4	76 13.8 N	13.4	*.13957*	*169*	169.7	P&B
Battle Harbor, *N*	52 15.3 N	304 23	Oct 24, 14	14.0	34 44.9 W	14.3	76 11.1 N	14.3	*.13513*	*169*	169.7	P&B
Bay of Islands	48 57 N	302 00	Nov 3, 14	10.8,12.6	30 38.9 W	14.2	75 10.2 N	11.3,12.1	.14734	13	169.567	P&B
			Nov 3, 14	13.1	30 36.4 W	....	....	14.2	*.14661*	*169*	....	P&B

* Local disturbance. [1] Berger and Son theodolite.

In the last column of the Table of Results the observer responsible for the observations is shown by his initials, namely, *WJP* for W. J. Peters, and *DWB* for D. W. Berky; when the observations were made jointly by two observers this is indicated by the combination of their last initials, namely, *P&B*, for Peters and Berky.

DESCRIPTIONS OF STATIONS.

One of the chief difficulties experienced by the observers of the Department of Terrestrial Magnetism, in the reoccupation of old stations for secular-variation data, has been the lack of necessary information to permit precise recovery of the point where the previous observations were made. Owing to the frequent occurrence of local disturbance, it may readily happen that erroneous secular-variation data will result from non-recovery of exact station. Accordingly, the observers of the Department furnish as complete descriptions as possible of stations occupied, especially of such as give promise of future availability. Information additional to that contained in the published descriptions or copies of station-sketches or of photographs of surroundings will gladly be furnished those who are interested in the reoccupation of any of the stations.

The descriptions are given in alphabetical order under the same geographical divisions adopted in the Table of Results. The general form followed in the descriptions is: Name of station, year when occupied, general location, detailed location, distances and references to surrounding objects, manner of marking, and finally the true bearings of prominent objects likely to be of permanent character. All bearings, unless specifically stated otherwise, are true ones, and are reckoned continuously from 0° to 360°, in the direction south, west, north, east. For some expeditions, owing to the absence of surrounding objects to which reference could be made and to the nature of the country traversed, the descriptions of stations naturally could not be made very full or precise; for some stations the data were necessarily so meager that worth-while descriptions could not be made up at all. When no mention is made of marking of station, it is to be understood that the station was either not marked at all or not in a permanent manner.

The majority of the distances given were measured originally in the English system; however, the distances obtained by conversion into the metric system are also given, but inclosed in parentheses, so as to show that they are converted figures. The following rules have been adopted in the conversions: Distances given to 0.01 foot are converted to the nearest 0.001 meter, 0.1 foot to the nearest 0.01 meter, 1 foot to the nearest 0.1 meter, estimated feet or yards to nearest meter, estimated fraction of a mile to nearest 0.1 kilometer, estimations of more than a mile to nearest kilometer. Short and important reference distances, when measured accurately, have been converted into nearest 0.1 centimeter; such measurements, however, as, for example, dimensions of marking-stones, etc., which are not of great importance, have been converted to the nearest centimeter. If a distance is given immediately preceding an azimuth of a mark, it is to be interpreted as distance from the magnetic station to the mark; it is in general estimated.

NORTH AMERICA.

CANADA.

Ashe Inlet, Northwestern Territories, 1914.—Station *A* is exact reoccupation of station established by U. S. Coast and Geodetic Survey in 1896, and reoccupied by "Arctic" Expedition in 1909 and 1912. On big island near north shore of Hudson Strait; on east side of inlet, about 23 meters west and 5 meters north of ruins of frame house, about 40 meters north of shore line, and 35 feet (10.7 meters) above high water; marked by drill hole 2 cm. in diameter in rock. True bearings: Tyrrel's beacon, 85° 25′.6; beacon on east side of harbor, 309° 47′.6; beacon on Rabbit Island, 337° 33′.7. A secondary station, *B*, was established 15.25 meters from drill-hole, in range between main station and Tyrrel's beacon.

Coats Island, Northwestern Territories, 1914.—On southeastern shore of Coats Island, about 100 yards (91 meters) north of high-water mark, 10 feet (3.0 meters) above high water, and 1½ miles (2.4 km.) southwest of a ridge or face of beach; marked by spruce stake surrounded by cairn 4 feet (1.2 meters) high. True bearings: rock cropping on ridge (about 3 km.), 212° 05′.0.

Erik Cove, Northwestern Territories, 1914.—On gravel bank at head of cove, 200 meters west of Hudson's Bay Company's post, about midway between the valley walls, 45 meters from high-water mark, and 19 meters from bank of stream that drains the valley; marked by spruce stake. True bearings: opening between topmast and mainmast at Hudson's Bay Company's post, 243° 05′.2; gable end of dwelling, 244° 12′.1; Hudson's Bay Company's property post, 107 meters, 273° 47′.3; south corner of white fence at grave, 278° 28′.9.

Eskimo Point, Northwestern Territories, 1914.—On an island which may be Sentinel Island, 600 meters west-northwest from a prominent cairn 2 meters high and 3 meters in diameter; marked by stake driven in sandy soil. True bearing: cairn, 288° 40′.6.

Mistake Bay, Northwestern Territories, 1914.—About one-fourth mile (0.4 km.) north of the head of northernmost inlet of the bay, about 11 feet (3.4 meters) above half-tide, ½ mile (0.8 km.) northwest of conspicuous knoll, 600 feet (183 meters) northwest of a pond, and 23 meters southeast of a cairn 7 feet (2.1 meters) high; marked by cross cut in bed-rock with letters C. I. W. alongside. True bearings: single rock about 14 feet (4.3 meters) high, 1.2 miles (1.9 km.), 50° 46′.6; conspicuous knoll, 304° 59′.5.

Smith Island, Northwestern Territories, 1914.—On west shore of island, about 2 meters above high water, and 7 meters from it; marked by cairn about 1.5 meters high. True bearing: rocky point on summit of small island, 158° 27′.4.

Sydney, Nova Scotia, 1914.—Close reoccupation of station of 1905, 1908, 1909 (marker has been removed in leveling operations to make a baseball-field in park).

NEWFOUNDLAND (INCLUDING LABRADOR COAST.)

Battle Harbor, Labrador, 1914.—Two stations, *C* and *D*, were occupied. *C* is a close reoccupation of station *C* of 1905, in a hollow extending northwest and southeast near center of Battle Island, about 500 feet (152 meters) east of English church, about same distance north of wireless telegraph-station, and about 15 feet (5 meters) east of a natural step in rock about 2 feet (0.6 meter) high, marked by a shallow drill-hole in the rock, and three shallow holes for the tripod legs. True bearings: tower of lighthouse on Double Island, 318° 36′.1; north gable of wireless station house, 336° 53′.0.

NORTH AMERICA.

NEWFOUNDLAND—*continued*.

Battle Harbor, Labrador, 1914—concluded.

D is 75.9 meters northwest of *C*, very nearly in the reversed azimuth of lighthouse on Double Island, on the highest point of Battle Island, 250.4 meters northwest of middle of gable end of wireless operator's house; marked by a 1-inch drill-hole in the solid rock, and also by 3 shallow drill-holes for the tripod legs. True bearings: south gable of two-story house across channel, 67° 30′.1; lone flagpole near edge of island, 118° 10′.7; tower of lighthouse on Double Island, 318° 46′.3; south gable of wireless station house, 333° 25′.3.

Auxiliary stations for reconnaisance magnetic survey to determine possible local disturbances were established; *E, F, G,* and *H*, were on Battle Island to the north-northeast of stations *C* and *D; I, J, K,* and *L* were on Big Caribou Island across tickle from Battle Island and about 700 meters south-southwest of stations *C* and *D; M* and *N* were on Great Caribou Island on the isthmus east of Cartridge Bight and about 4 kilometers west-southwest of stations *C* and *D*.

Bay of Islands, Labrador, 1914.—Close reoccupation of C. I. W. stations of 1905 and 1909; at a place called "Riverhead," near mouth of Humber River, about one-fourth mile (0.4 km.) west of Bay of Islands railroad station, 300 yards (274 meters) from wharf of Reid-Newfoundland Company near base of small point of land projecting into the bay, about 39 meters from railroad track, 25 meters from northern extremity of point, and 8 meters from east and west shores.

Boulter Rock, Labrador, 1914.—Two stations, designated *A* and *B*, were occupied on Boulter Rock. *A* is on south end of island, about 10 feet (3 meters) from water's edge, at right-angled intersection of two seams in flat rock. True bearings: northwest end of ridge of house on Old Jeff Island, 100 feet (30.5 meters), 41° 36′.3; south end of ridge of house on summit of Boulter Rock, 173° 09′.1; southwest end of ridge of higher of two houses almost in line on flat island, ¼ mile (0.4 km.), 215° 11′.7; west end of ridge of house on Stag Island, 500 feet (152 meters), 269° 11′.9. *B* is 35 feet (10.7 meters) north of *A*.

Domino, Labrador, 1914.—On east side of entrance to Domino Harbor, about 200 feet (61 meters) above sea, and 11.1 meters south 42° east from a prominent stone cairn. True bearings: cairn on Mustering Point, 1½ miles (2.4 km.), 117° 29′.4; chimney funnel on house near Rocky Point, Spotted Island, 1½ miles (2.4 km.), 149° 38′.6; school flagstaff at Spotted Island Harbor, 198° 13′.4; wireless pole, Domino Harbor, 356° 55′.8.

Gready, Labrador, 1914.—The station of 1881 by S. W. Very was reoccupied; it is now within 7.3 meters of a new house, but there was not time to establish a new station. True bearing: flagstaff, 94° 18′.2.

Great Island, Labrador, 1914.—Near northwest shore of Great Island (about one mile (1.6 km.) northwest of Battle Island), 7 feet (2.1 meters) east of large rift in rock, and about 50 yards (46 meters) south-east of sea end of rift; marked by shallow cross cut in solid rock. True bearings: gable of house on opposite shore of Lewis Sound, 140° 33′.9.

Green Island, Labrador, 1914.—On the cliff on east shore of island, 22 meters southeast of a cairn, 2.5 meters northwest of a rift in rock, and in range between the cairn and station Battle Harbor *D*. True bearing: Battle Harbor *D*, 286° 13′.5.

NORTH AMERICA.

NEWFOUNDLAND—*continued.*

Gull Rocks, Labrador, 1914.—Two stations, designated *A* and *B*, were occupied on larger of two rock islands in Lewis Sound, 3 miles (4.8 km.) northwest of station Battle Harbor *D*. *A* is in middle of 15-foot (4.6 meters) rift in solid rock, 20 feet (6.1 meters) northwest of a cairn built on highest part of island. *B* is 1.6 meters southeast of cairn, in range between cairn and station Battle Harbor *D*. True bearing: Battle Harbor *D*, 301° 34′.0.

Hopedale, Labrador, 1914.—On point of land about 200 yards (183 meters) east of the Moravian mission, near highest point of exposed rock. True bearings: base of pole of beacon west of mission, 94° 44′.2; pinnacle of Moravian church, 104° 23′.9; beacon on hill, 136° 20′.5.

Port Burwell, Labrador, 1914.—Practical reoccupation of station established by Gordon and Stupart in 1884-85, and reoccupied by British Navy in 1905, and by "Arctic" Expedition in 1909 and 1912; on west shore of Port Burwell, on neck of land between harbor

NORTH AMERICA.

NEWFOUNDLAND—*concluded.*

Port Burwell, Labrador, 1914—concluded.

and a salt-water pond; covered by wooden beacon anchored by mass of broken rock inside the structure. Two points, designated *A* and *B*, were occupied in 1914. *A* is 3.8 meters from beacon and in line between it and a low beacon on other side of harbor. True bearings: beacon at west end of pond, 75° 05′.3; beacon on brow of hill on east end of point of land, 219° 48′.4; low beacon east of point of land, 225° 55′.3.

B is about 70 meters south of *A*; marked by charred stick covered by cairn of stone 1.5 meters high. True bearing: low beacon on rock east of point of land, 218° 10′.8.

Sangmijok, Labrador, 1914.—On south shore of raised beach on neck of land between 2 hills, 12 feet (3.7 meters) above high water, and 5 feet (1.5 meters) south 78° west (magnetic) from a cairn 4 feet (1.2 meters) high; marked by charred stick projecting 6 inches (15 cm.) above ground.

EXTRACTS FROM INSTRUCTIONS FOR THE OBSERVATIONAL WORK AND NARRATIVE REPORT.

The following extracts from the Director's instructions of June 18, 1914 to the author as regards the program of observational work will serve to indicate wherein it was necessary to depart somewhat from methods followed on the *Galilee* and *Carnegie*, and which are given in detail in Volume III (pp. 115–127 and 317–324). These also indicate some of the observational difficulties encountered in a region of high magnetic latitude such as that covered by the expedition.

PROGRAM OF MAGNETIC WORK.

A. Land Work

General remarks.—The following outline of desirable work can be tentative only. Just what should be attempted is left to the chief of party. While all the points occupied by the *Arctic* in 1912 are given, it is expected that only a suitable number be reoccupied. Stress should be especially put upon securing data where none or but few have heretofore been secured, as for example, Ungava Bay, Baffin Island, and Hudson Bay (eastern part, western part from Fort Severn northward, and northern part). The precise order in which the work is to be done is again left to the chief of party.

As the diurnal range of declination and horizontal intensity will be found large in the Hudson Bay region, as also the effect of any magnetic storms, it will be essential for securing the best results that the observations be distributed over the day as effectively as possible. . . . It will be well to observe the a. m. and p. m. extreme values of the magnetic declination whenever possible.

Invariably, when time and conditions permit, there should be observed at each station declination, horizontal intensity, inclination, and total intensity, as did the *Arctic* observer.

Attention is also called to the method of observing inclination in any two planes at right angles to each other whenever the magnetic meridian, because of small horizontal intensity, can not be satisfactorily determined. If in such a case the horizontal circle-reading also be taken of a mark the true azimuth of which is determined, there may result at the same time a fairly good value of declination. The circle-reading of the magnetic meridian can be deduced later from the dips observed in the two planes, the circle-readings of these planes being, of course, noted in the record.

The observer should not fail to note in his records any suspicion he may have respecting disturbing influences (local, or magnetic storm effect). In view of the comparatively small number of stations for the region covered, it is of the utmost importance to place stations as well as possible. Still, it will be of importance to navigation to have pointed out, as well, areas of local disturbance.

Record should be made also of time of any display of polar lights and as good a description as possible be given.

Possible future reoccupation of stations should be kept in mind when preparing descriptions of stations, or when marking them by the best means at hand.

(A list of secular-variation and distribution stations in the maritime provinces of Canada, Newfoundland, Labrador, and the islands and shores bordering on Hudson Bay and Hudson Strait accompanied the instructions; this list gave extended remarks regarding previous occupations and details so far as known of local disturbances.)

B: Sea Work.

No explicit directions can be given in view of the inadequate knowledge at hand respecting the *George B. Cluett* and her arrangements. . . . The observations should, in general, be made on as many headings of the ship as conditions may permit,

preferably for as complete a swing (8 equidistant points) as may be possible. Follow as far as possible the methods used on the *Galilee* and the *Carnegie*. The following scheme might be tried: (*a*) make declination observations with deflector (card undeflected); (*b*) if small horizontal intensity permits, make deflection observations with deflector for value of horizontal intensity; (*c*) deflection observations with Lloyd Creak dip-circle, for inclination and total intensity.

Probably time and conditions will permit only occasionally carrying out such a full program, but it may be possible to follow the scheme thus: At one station make observations (*a*); at the second, observations (*b*); at the third, observations (*c*); at the fourth, (*c*); at the fifth, (*b*); and at the sixth, (*a*), etc. It should be remembered, however, that the (*a*) observations for declination are the most important from a navigational standpoint and they should invariably be given preference. Some experience respecting the behavior of the deflector for observations (*a*) and (*b*) under the conditions of small horizontal intensity encountered is much desired.

The maps showing status of magnetic observations in Hudson Bay show that it is highly desirable to obtain some control, even though it can be but an approximate one, on the values in the middle of Hudson Bay as deduced from the distant shore observations. . . . What work can be done in the Atlantic and in Hudson Strait must be left to the chief of party.

It will suffice to control the ship instrumental constants, if possible, at Battle Harbor, at a suitable port in Hudson Strait, at a port in southern part of Hudson Bay and at one in northern part, and again upon return to home port.

The value of A_s of the deviation formula will be obtained at the ports where the constants are controlled. In brief, the methods of the Department's ocean work are to be followed as far as conditions permit.

Were the *Carnegie* suitable for this expedition, the sea work would be regarded as more important than the land work, but in the present case, having a vessel the magnetic character of which is not known, *the land work will have to be given the preference whenever a decision must be reached between land and sea work.*

C. MISCELLANEOUS WORK.

Attention has already been called to the large diurnal variation in declination and horizontal intensity. It will, therefore, be desirable to embrace any occasion which may present itself, without retardation of the work outlined in the previous pages, to obtain declination observations over as long a period and at such intervals as conditions will permit. There is sent for the information of the party a copy of "The Ziegler Polar Expedition," as also various pamphlets relating to magnetic work and to the expedition of the *Arctic*, which may serve as a guide in drawing up a program for these auxiliary observations.

It will also be arranged that our observers make magnetic-declination observations on the day of the total solar eclipse, August 21, 1914 (consult the Ephemeris), for a period of 2 or 3 hours before the beginning of the eclipse and continue until the same time after. Of course, these observations will be possible only at a shore station and conditions, therefore, may prevent making them.

EXTRACTS FROM REPORTS ON THE EXPEDITION.

W. J. PETERS: REPORT ON THE HUDSON BAY EXPEDITION, JUNE 20 TO NOVEMBER 11, 1914.

According to instructions dated June 18, 1914, I met Mr. D. W. Berky in Boston on June 20, and together we arrived at Battle Harbor on June 28, where after examining the various sites previously used for magnetic stations, we began field work on June 30. No magnetic stations were occupied en route from Boston to Battle Harbor, owing to the desirability of reaching the latter place before the arrival of the chartered vessel.

Ship and land instruments were intercompared at Battle Harbor on the old station *C* which furnishes secular data and on a new one *D* selected for the purpose of intercomparisons. The other stations *A*, *B*, and B_m were not available because of scrap iron, débris, and the extension of the hospital buildings. Stations *C*, *D*, Gull Rocks, Green Island, and Great Island are well distributed around the position of the ship swings made at Battle Harbor.

The three-masted schooner, *George B. Cluett*, was chartered from the International Grenfell Association for a cruise into Hudson Bay of three months for $5,000. This vessel was built to meet normal ice conditions on the Labrador coast in the summer. The framing and outer skin are of oak and there is an iron shoe on the stem and under the whole length of the keel, but no other means are provided for combating ice. The galley, donkey-engine room, and some of the crew quarters are all in one structure just forward of the foremast and built on the main deck. The cabin is just abaft the mizzen and is sunk about a foot or two below the main deck and extends about 2½ feet above the poop, with but little clearance for the spanker boom.

The engine room is below the cabin and contains, besides the engine, iron water tanks of 1,200 gallons capacity, and engine-room tools, vises, etc. The vessel was in ballast consisting of broken rock. The *George B. Cluett* arrived at Battle Harbor on July 8, and the instrumental equipment, tents, and personal baggage were put on board. A critical examination of the vessel for the location of the gimbal-stand was made at once. The galley forward and the cabin aft practically confined the choice to the main deck between the main and the mizzen. A position was finally chosen in the middle section of the main hatch. This section and the adjoining after one were battened down. The forward one was opened occasionally to give access to the hold. The following measurements were made to locate the gimbal on the ship plans as well as some of the nearest large masses of iron on or above deck:

	feet
From gimbal-stand to mizzen	14
From gimbal-stand to forward edge of main hatch coaming	5.2
From gimbal-stand to engine in launch	9.2
From gimbal-stand to after end of launch (length of launch, 23.6 feet; beam, 6.2 feet)	15.2
From gimbal-stand to main-sheet horse, aft	12.5
From gimbal-stand to main pump (2 feet to starboard)	15.0
From gimbal-stand to forward pump (1.4 feet to port), forward	10.3
From gimbal-stand to kedge lashed to main, forward	14.0
From gimbal-stand to near end of steel life-boat amidships	18.6
From gimbal-stand to far end of steel life-boat amidships	33.0
From deck to mast band of main	7.2
From deck to mast band of mizzen	6.9

The constant A_s of the ship for dip and total force and for horizontal force were determined by swings at Battle Harbor on July 11, 17, and 22 before the cruise and after the cruise on October 7 at the same place for the magnetic declination, inclination, and total force. No other harbor swings were practical either at Battle Harbor or at any of the ports visited on the cruise. Swings in Hudson Strait were used in the final reductions as harbor swings to control the constant A_s. There are but few places along the track of the cruise that are suitable for harbor swings and all would require considerable preparation. Those on the Atlantic coast of Labrador were impossible on account of ice and wind during the outward passage and on account of stormy weather on the return. In Hudson Strait and in some portions of Hudson Bay the currents are so strong that it would be necessary to erect beacons on shore to control the position of swing and any suitable places that could be surrounded by land stations would have to be examined for rocks and shoals before making a swing as a matter of precaution for the safety of the vessel.

Before the swing of July 11 the dip circle was leveled in smooth water and the ship was taken out in the morning. But a fog came in so thick that a swing for inclination

and intensity was impossible. Advantage was taken of the smooth water and the short swing which alone was possible to get the meridian readings at the gimbal-stand by the compass attachment for each heading of the ship by the steering compass. The first swing for inclination and total force was made according to these separate readings, which are entered in the notes. Subsequent swings for inclination and total force were made with meridian readings on each heading exactly 45° different from the preceding heading. These are likewise entered in the notes.

As reports from the north showed the impossibility of making much distance northward in July, the vessel was held at Battle Harbor until the inclination and intensity swings made in cloudy weather were completed, July 22. During this time declination swings were impossible even when the sun was visible, principally on account of the strong winds against which the *George B. Cluett* could make no headway. It was decided on July 22 to sail as soon as ice conditions would permit. On July 30 the prospects turned out to be good and the *George B. Cluett*, having weighed anchor late in the afternoon, started on the journey north. The passage to Hudson Strait was made by working up between the pack and the coast, or working in the loose pack and finally working through the narrow channels of the northern coast. Port Burwell was reached by passing through Grenfell Channel (not charted) on the morning of August 21. It had been planned to get to Port Burwell on the afternoon of August 20 in order to prepare for the eclipse observations, but the current in Grenfell Channel changed before we could get through and started to run back at a speed of 6 to 8 knots, which compelled us to anchor. Getting under way at the first break of dawn, we managed to reach Burwell a few minutes before the eclipse. The Canadian Government steamers *Minto* and *Arcadia* had returned to Port Burwell after having ineffectually tried to push through the pack in Hudson Strait. But as the strait was now clearing we set sail August 24. No more ice was actually encountered, though the "blink" could be seen until we arrived abreast of Charles Island. From Charles Island to the end of the cruise no more pack-ice was seen, but icebergs of enormous size were seen in the strait and in the Atlantic on our return.

The original plan of cruise was followed until it became evident that we could not reach the western shore of the bay if we continued south of the "Two Brothers." It was also found that the islands on or near the 80th meridian are badly charted and that much time might be lost in trying to find them and make a landing. A more advantageous distribution of magnetic stations seemed possible if we crossed the bay to the west shore. Accordingly, on September 8 a course was set to make Eskimo Cape. Eskimo Cape or Sentinel Island was made on the evening of September 12. Next morning, September 13, Mr. Berky and I went ashore before breakfast and were detained by a storm until noon of September 15, without food or blankets. This storm was so severe that the Hudson's Bay Company's steamer *Pelican* reported later that she had both anchors down and engine full speed ahead. Eskimo Cape was left on the afternoon of the 15th, as Captain Pickels had decided that the *George B. Cluett* must return at once. Two stops only were made on the return voyage, one at Coats Island, where many bear and caribou were seen, and the other at Erik Cove, both made with the intention of getting fresh water. The stop at Coats Island afforded an opportunity to establish a magnetic station, but at Erik Cove we set up the instruments only to find that a magnetic storm was in progress, September 23.

Falling snow hastened our departure, and as we weighed anchor, Mr. S. Sainsbury was taken on board at Captain Pickels's request. He had been prospecting the winter before and had no means of returning except by dog-sled in the coming winter. Mr. E. W. Hawkes of the Canadian Geological Survey had joined the ship August 3 at Gready Island, where the *George B. Cluett* had put in for the night. The remainder of the passage through the Hudson Strait and off the Labrador coast in the Atlantic

was made in the usual cloudy, foggy, and thick weather which prevails in the fall and winter months and which, together with the strong currents, lack of lights, beacons, or prominent land marks, makes the ship's position very doubtful. Battle Harbor was finally made in the afternoon of October 3. A gale sprang up soon after our arrival and raged to noon of October 7, when it suddenly abated. The ship was then swung in the afternoon for inclination, total force, and declination. Experiments having shown that swings for the deflector would take too much time, no deflector swings were made on the cruise or after the return. The *George B. Cluett* was turned over to owners on October 8, exactly three months after she had been put at our disposal.

Unusual difficulties were experienced both in observations on land and sea and in office work aboard the vessel. The prevalence of strong winds at temperatures ranging from +10° to 0° centigrade was not only a bodily discomfort in handling the instruments and particularly the needles, but it was also a menace to the tents and to the instruments mounted therein. The soil is everywhere a very thin layer over solid rock, usually not deep enough to hold the tent-pegs. Loose rock that might be used as a substitute is not found near the Battle Harbor stations. Indeed, except for the magnetometer, it was found best to observe without tent protection at these stations as well as others on the homeward passages, where cloudy weather generally prevailed and protection against the Sun was not necessary. At sea the principal difficulty in the work of observations was the numbness in the observer's fingers, due to exposure to winds at low temperatures.

The ice conditions on the Labrador Atlantic coast were extraordinary in the summer of 1914. Usually the pack has drifted south and has disappeared off Battle Harbor by the end of June. This season the pack was still on the coast as far north as 60° latitude on August 17, a condition generally admitted to have never existed heretofore in the last thirty years.

Hudson Strait was blocked by ice until quite late in August, compelling the Canadian Government steamers *Arcadia* and *Minto* to return to Port Burwell for more coal. An interesting fact in connection with these ice conditions, reported by Mr. S. Sainsbury, who had wintered in Baffin Land, was that the Dundee whaler *Active* passed through the strait in the first week of July of this year, the strait being practically free of ice at the time. The Dundee whalers are built to encounter heavy ice, and the *Active* probably passed through the ocean packs and entered the strait before the Fox Channel ice had started.

On the cruise of the *George B. Cluett* to Hudson Bay and return, the land observations were confined to those opportunities offered when the vessel was forced to seek harbor. Hence these stations could not be selected to the best advantage for repeat stations or for distribution of original stations. Ordinarily, only a short time was available before dark, and as the first consideration was the work in Hudson Bay, no delay was made, by the shore observations, in the progress of the vessel along the Atlantic coast of Labrador. The complete land-station program could not be carried out in many cases. At sea the observations were confined to swings, for the reason that the distribution of iron on the vessel could not be preserved without change as the vessel's course was changed under sail. All the booms have a large amount of iron work, and under sail they are frequently shifted for changes in wind or course. The launch, dinghy, and life-boat were not in chocks nor hung from davits. Hence their positions were liable to small alterations every time they were used, though precautions were taken to insure their exact return to their respective positions. It was generally impossible to hold a course long enough for ordinary ocean observations when the vessel was navigated in the ice or in the narrow, tortuous channels of the northern portions of the Atlantic coast of Labrador. Declination swings with deflector 3 were made every time the sun was available for the observation, according to the instructions,

which gave preference to declination work at sea. These observations were possible only on the outward passage, for during the homeward passage the sky was overcast practically the whole time. When it became evident that only a few swings could be made in Hudson Strait and Hudson Bay, I considered it advisable, for inclination and intensity, to observe on every occasion deflections with sea dip-circle 169, as these yield results in inclination, total force, and horizontal intensity, and to observe with the dip needle only on those occasions where both helms were used. Experimental observations with deflector 3 for horizontal intensity were made on two occasions. Though observations could be made with it, yet so much time was required for the card to come to rest after each operation of the deflection observations, that swings were quite impractical. In fact, the experimental observations on course in the high latitudes were possible only by knowing the approximate value of the deflection-angle u, as the card was easily kept in continued rotation by trying to "follow up" and make the setting.

The prospect of reaching Port Burwell during the afternoon before the eclipse of August 12 appeared so favorable that it seemed undesirable to wait at Sangmijok, where an original station would be necessary, which, moreover, would be at no great distance from a repeat station. The vessel was, however, caught in the current of Grenfell Channel, which prevented our reaching Port Burwell until but a few minutes before the eclipse.

Mr. D. W. Berky left the office June 19 with the instruments and returned November 14. The total time from the office and back was therefore 148 days. There are 36 stations, so the average number of days per station is slightly over 4. The average time spent at each station was 4.7 hours. The times of actual work at the field stations vary considerably, from the long comparisons at Battle Harbor to the short declination observations at sea. Travel was by rail and by steamer to Battle Harbor and by a chartered vessel from Battle Harbor into Hudson Bay. The distances over each portion of the route going and returning are: By rail, 2,960 miles; by steamer, 800 miles; and by chartered vessel, 3,700 miles; making a total of 7,460 miles. There were 23 stations made on the 3,700-mile cruise of the *George B. Cluett*, not counting the harbor swings or substation at Port Burwell, or an average of one station per 161 miles.

Expenditures for the Hudson Bay Expedition were made as follows: field expenses, \$806.22; vessel charter, \$5,000; office expense, \$205.75; making a total of \$6,011.75. The total number of stations is 36; hence the average cost per station is \$167.

The whole region traversed on the cruise into Hudson Bay is composed of very old igneous rocks with veins carrying magnetic ores of iron. These minerals were found in very small fragments, not much larger than a pea, but probably larger masses are embedded. One exception to this formation was Coats Island, which is composed of weathered limestones. Abnormal values of the magnetic elements were noticed at Domino. Erratic motions of the steering compass were noted in latitude 58° 30′ N., longitude 80° 00′ W., and in latitude 62° 00′ N., longitude 90° 30′ W. In the latter region, where the horizontal force is very feeble, the compass-card was continually sticking.

Captain F. Anderson, of the Canadian steamer *Arcadia*, called and offered to help the expedition; his mechanic supplied a missing portion of the magnetizing block for dip circle 4655, and his engineer supplied the *George B. Cluett* with a small quantity of lubricating oil. The assistant collector of customs of St. Johns wired the customs officer at Humbermouth to "extend all facilities" to our expedition. Mr. J. T. Coucher of Baine Johnston Company, St. Johns, N. F., housed us in Battle Harbor and assisted very materially by supplying labor, etc. He also offered to assist in any way that he could in future operations, such as advice in building a magnetic observatory. It was reported that the Moravian missionaries at Nain had made and published a series of observations on the aurora. On account of the war and certain regulations concerning aliens, we were not allowed to visit Victoria Park until permission had been sent at the

request of Professor R. F. Stupart to the local military. The successful navigation of the vessel through ice, foggy weather, and particularly in uncharted waters, is due to Captain H. Pickels, who was keenly interested in our work. He is familiar with the Atlantic coast of Labrador and portions of Hudson Strait, and it was this knowledge that enabled him on one occasion to pass two steamers that were held in the ice. I wish to acknowledge the faithful services of Mr. D. W. Berky, the assistance rendered by Mr. E. W. Hawkes in pitching tents, and of the mates and engineer in building cairns on several occasions.

The great difficulties of working in the Hudson Bay region are its inaccessibility and the lack of food, supplies, etc. The simplest method of meeting these is by wintering a vessel in the region to be surveyed, and then working from the vessel by dog-sleds in the frozen season and by whale-boats and canoes in the summer. Such a vessel need not necessarily be large, but should be stout, supplied with a reliable motor, and well lighted. A Gloucester fishing schooner might be converted for the purpose at no great expense, and if the railway were completed to Churchill before the magnetic work was finished in the Hudson Bay region, the fishing schooner could be supplied by rail and thus remain in Hudson Bay until the survey was completed. Instruments should be stowed in waterproof cases for boat work in surf (as on western shores of Hudson Bay) or for canoeing in rapids.

ABSTRACT OF LOG OF THE GEORGE B. CLUETT.

Date	Noon position or anchorage		Day's run[1]	Remarks
	Lat. N.	Long. E. of Gr.		
1914	° ′	° ′	*miles*	
Jul 8	Battle Harbor			Large pans of ice driving into harbor. Cloudy. Strong breeze NE to N.
9	Do.			Cloudy. Moderate breeze NE.
10	Do.			Strong northerly gale. Day ends with moderate breeze, heavy swells. Drizzling, cloudy.
11	Do.		6	Hove anchor at 1 p. m. and proceeded into Lewis Sound to swing. Return to Battle Harbor. Thick fog, cloudy. Wind NE to E, force 4.
12	Do.			Fog and rain. Wind SE.
13	Do.			Light breeze, SE to S. Cloudy. Day ends with thick fog from northward.
14	Do.			Strong breeze E, S, and SW. Ice in offing. Cloudy.
15	Do.			Wind from north. Squalls.
16	Do.			Overcast, strong breeze from north.
17	Do.		6	Proceeded to Lewis Sound to swing in calm. Returned in strong breeze from SW. Cloudy.
18	Do.			Overcast. Wind WSW to NE.
19	Do.			Cloudy. Rain and fog. Wind NE.
20	Do.			Thick fog and rain. Wind SW to W. Day ends calm and clear.
21	Do.			Misty and cloudy. Wind east. Day ends with fog.
22	Do.		6	Proceeded to Lewis Sound to swing. Returned in overcast gloomy weather. Light wind NE.
23	Do.			Thick fog. Ice begins to come into harbor. Wind NE.
24	Do.			Heavy ice completely fills harbor. No water visible from crow's-nest. Wind ENE.
25	Do.			Harbor remains blocked with ice. Fog, mist, and rain. Calm or light airs.
26	Do.			Harbor remains blocked. Clear, moderate breeze from ENE.
27	Do.			Harbor remains blocked. Fog. Moderate breeze from E.
28	Do.			Clear. Light winds from ENE. Heavy ice extends to horizon as seen from hills.
29	Do.			No change in ice. Clear, northerly breeze.
30	Do.			Ice begins moving at 10 a. m. Hove anchor at 4 p. m. Steamed through loose ice.
31	Hill Harbor		53	Anchored at 3 p. m. Clear, light wind WNW.
Aug 1	Do.			At anchor, blocked by ice. Clear. Light winds and calms.
2	Domino Run		25	Anchored in Domino Run. Fair, light northerly wind.
3	Gready Harbor		30	Anchored at 4 p. m. account of ice. Cloudy. Heavy ice. Calm, cloudy.
4	Independent Harbor		17	Clear, followed by cloudy weather and hail. Light variable winds.
5	Holton Roads		53	Thick pack-ice off Horse-Chopps. Passed through heavy pan-ice. Cloudy, overcast, and rain. Wind NW increasing.

[1] Distance from the last position or anchorage.

ABSTRACT OF LOG OF THE GEORGE B. CLUETT—*Concluded.*

Date		Noon position or anchorage Lat. N.	Long. E. of Gr.	Day's run	Remarks
1914		° ′	° ′	*miles*	
	6	Cape Harrison		30	Passed through large ice-fields. Encountered heavy ice-pack and then worked in toward shore. Light northerly winds, fog, rain.
	7	Aillik		45	Made Cape Harrison at 8 a. m. Heavy ice-pack at 2 p. m. Light winds NE to SE.
	8	Hopedale		40	Proceeded through inside passages to Hopedale. Heavy packed ice off shore and to north. Light northerly airs. Cloudy.
	9	Do			Remain at Hopedale account of ice. Fog, calm.
	10	Davis Inlet		45	Hove anchor at 3 a. m., proceed by inside passage to Davis Inlet. Cloudy, misty, light northerly airs.
	11	Uncertain			Working through ice-fields. Fog, rain, day ends with no ice. Moderate breeze. Heavy bergs in offing.
	12	Do			No ice but many heavy bergs. Encounter ice about 3 p. m. Light NNW airs. Clear.
	13	Do			Cloudy, heavy fog. Strong breeze W to N. Clear followed by fog.
	14	Do			Fog. Moderate breeze. Loose ice. Hove to.
	15	58 15	229 11		Swing. Fog and light wind.
	16	Uncertain			Moored to ice-pan. Large bergs on all sides.
	17	Do			In ice-pack until noon. Run to Rain Bay. Clear, light wind.
	18	Kelvagtuc			Heavy ice off shore. Light winds and calm. Day ends with rain and heavy fog.
	19	Kakkinak			Anchor in dense fog. Gale.
	20	60 20	295 20	50	Uncharted narrow channel. Under way between 9 a. m. and 8 p. m. Light northerly airs. Foggy and cloudy.
	21	Port Burwell		6	Misty. Light southerly airs.
	22	Do			Dense fog, rain, and moderate breeze from north.
	23	Do			Rain, fog, and strong E to NE breeze.
	24	61 10	294 03	61	Hove anchor 3 a. m. Swung ship. Cloudy and foggy. Moderate easterly breeze.
	25	61 39	291 59	68	Swung ship. Thick fog. Light westerly and northerly breeze.
	26	Uncertain			Dense fog. Lying to in ice.
	27	Ashe Inlet		99	Arrived Ashe Inlet 7 a. m. Rain, thick fog. Heavy ice at mouth of inlet.
	28	Do			Strong WNW gale. Fog. Ice passing by mouth of inlet.
	29	62 31	289 05	13	Hove anchor 5 a. m. Snow. Strong breeze from NW and N.
	30	62 36	288 05	30	Clear, light wind N to SE. Swung ship.
	31	62 49	285 40	68	Clear, light SE wind. Swung ship.
Sep	1	Erik Cove		90	Anchor 8 p. m. Clear and calm.
	2	62 18	281 30	42	Hove anchor at 4 a. m. Clear, calm or light NE airs.
	3	Smith Island		90	Anchored at 8 a. m. Hove anchor at 11 p. m. Cloudy, light ENE airs.
	4	Uncertain			Hove to in gale from NE. Mist and rain.
	5	Mistake Bay		145	Anchored at 6 p. m. Gale from ENE moderating. Cloudy, rain. Day ends clear.
	6	Do			Light NE breeze, clear.
	7	Cape Dufferin		64	Hove anchor at 4 a. m. and came to anchor about 4 p. m. off Cape Dufferin. Cloudy, rain, light NE airs.
	8	58 26	279 29	56	Hove anchor at 7 a. m. Passed many islands. Thick fog. Light NE wind.
	9	57 52	277 09	83	Cloudy, followed by clearing. Moderate NW breeze. Swung ship.
	10	58 08	275 20	59	Clear. Light variable airs. Swung ship.
	11	59 57	270 45	188	Fog followed by clearing. Light SW airs. Swung ship.
	12	Cape Eskimo		170	Anchored at 9 p. m. Clear, calm.
	13	Do			Overcast. NE wind increasing.
	14	Do			NE gale.
	15	Do			NE gale subsides. Hove anchor at 4 p. m. Cloudy.
	16	61 30	271 35	165	Cloudy. Light S to SW breezes.
	17	61 55	275 10	110	Cloudy. Strong west wind.
	18	62 03	277 28	82	Cloudy. Light SW wind. Swung ship.
	19	Coats Island		51	Anchored at 10 a. m. and left at 6 p. m. Cloudy. Light variable airs.
	20	Uncertain			Cloudy. Rain. Strong ESE breeze.
	21	Do			Cloudy. Rain and snow. Strong NE breeze.
	22	62 03	279 00	56	Cloudy. Moderate northerly wind.
	23	Erik Cove		119	Anchored at 11 a. m. Snow. Cloudy.
	24	Do			Hove anchor at 11 a. m. Snow. Strong northerly breeze.
	25	62 40	286 48	126	Light NW winds. Snow.
	26	Uncertain			Light northerly winds. Snow.
	27	71 07	293 20	210	Cloudy. Fresh northerly breeze. Swung ship.
	28	60 57	295 57	85	Fresh breeze. Day ends with mist and light breeze.
	29	58 12	298 40	125	Cloudy. Snow. Light variable wind.
	30	56 15	301 10	144	Cloudy. Thick fog. Moderate NW breeze.
Oct	1	Uncertain			Cloudy. Light NNE wind.
	2	Do			Cloudy. Fresh northerly wind.
	3	Battle Harbor		265	Anchored at Battle Harbor 4 p. m.

Total distance, 3,258 miles. Time spent on voyage, 65 days. Average day's run, 50.1 miles.

NOTES ON THE NORTHERN LIGHTS.

These notes during the Hudson Bay Expedition cover a period extending from June 28 to October 28, 1914. During this period of 123 days there were 43 clear nights and the Northern Lights were seen on 16 nights. The remaining 80 nights were cloudy or foggy and occasionally with rain or snow. Because of limited help, observations were not made after 23 o'clock, local mean time, civil reckoning, except in one or two cases. In the tabulation of these notes as given below all directions are magnetic.

Observations of Northern Lights during July to October, 1914.

Date		Lat. N.		Long. E. of Gr.		Local mean time		Notes
1914		°	′	°	′	h	h	
Jul	9	52	16	304	25	20 to	23	Clear; no aurora.
	20	52	16	304	25	20	23	Fairly well defined auroral arch extending from about 15° E to 15° W of N, about 5° wide and 30° high. Certain parts are more brilliant and are continually shifting or pulsating along the arch, but not throughout the entire length.
	26	52	16	304	25	20	23	Cloudy, clear toward morning; no aurora.
	28	52	16	304	25	20	23	Clear; no aurora.
	29	52	16	304	25	20	23	A remarkably clear night. There is an auroral arch of perfect symmetry. The highest part about 30° high is 10° E of N. The arch extends from 35° E to 15° W of N.
	30	52	40	304	20	20	23	Clear, no aurora.
	31	53	06	304	14	20	23	Do.
Aug	1	53	06	304	14	20	23	Do.
	2	53	28	304	14	20	23	Do.
	5	54	00	303	00	20	22	Clear, followed by cloudy weather, faint auroral glow in the N.
	11	56	00	300	00	20	23	Clear, no aurora.
	12	56	50	299	30	20	23	Do.
	17	59	00	297	30	..	23	Faint auroral glow in N. Clear at 2^h on Aug. 18; no aurora.
	21	60	30	295	30	20	22	Clear at 20^h, no aurora. Cloudy at 22^h.
	28	62	30	289	30	20	22	Clear at 20^h, thin clouds soon appear, cloudy at 22^h.
	29	62	30	289	00	20	23	Partly cloudy. At 22^h auroral light just discernible between clouds in SSE.
	30	62	30	288	00	20	23	Clear, no aurora.
	31	62	39	284	30	20	23	Do.
Sep	1	62	33	283	32	20	23	Do.
	2	62	00	281	20	20	23	Do.
	5	59	13	281	48	20	22	Clear, magnificient spectacle of aurora. Streaks of prismatic colors pass through the zenith from SE to NW and reach to within 20° of each horizon. The lights are in continuous pulsating motion; sometimes they shimmer or tremble.
	6	59	13	281	48	20	22	Clear, no aurora.
	8	58	40	280	00	20	22	Clear, no aurora seen before 21^h. Curtain of waving variety visible at 22^h, brightest in SSW; as usual the "hem" or bottom of curtain is brightest part; waving folds are distinctly visible. Display is not seen in northern portions of sky.
	9	58	10	275	00	..	..	Clear, aurora begins at 20^h, extending from zenith to about 25° above western horizon. It appears as a brilliant waving curtain with lower edge sharply defined and apparent folds distinctly visible. At 21^h it extends clear across the zenith from E to W in several waving bands.
	11	60	30	269	40	20	23	Clear, no aurora until after 23^h, when there is a brilliant spectacle of waving-curtain variety.
	16	61	25	271	30	..	..	Clear, at 20^h20^m aurora appears as a perfectly smooth band parallel to the horizon and about 15° above it, extending from WSW to ESE.
	17	61	55	275	10	20	23	Clear, no aurora between 20^h and 23^h.
	18	..	..	...	..	..	..	Brilliant aurora, curtain variety, at 1^h.
	18	62	00	277	30	20	23	Cloudy but clearing later; no aurora.
	21	62	10	278	30	20	23	Partly cloudy, faint aurora visible in rifts of clouds in northern sky. Comet seen in constellation of Dipper.
	22	62	40	280	00	20	..	Partly cloudy, glow seen between rifts in clouds but soon sky is overcast.
	27	60	50	280	00	19.5	24	Clear, aurora appears as narrow horizontal band of almost continuous light-intensity from E to SE, and about 7° above the southern horizon and seems to pulsate with intensity.
	28	..	..	...	..	0	4	
Oct	1	55	50	301	50	20	23	Clear, no aurora.
	2	54	30	303	50	20	23	Do.
	3	53	00	305	00	20	23	Do.
	4	52	16	304	25	20	23	Do.

Observations of Northern Lights during July to October, 1914—Concluded.

Date		Lat. N.		Long. E. of Gr.		Local mean time		Notes
1914		°	′	°	′	*h*	*h*	
Oct	5	52	16	304	25	20	23	Clear, no aurora.
	8	52	16	304	25	20	23	Do.
	9	52	16	304	25	20	23	Do.
	13	52	16	304	25	20	23	Do.
	16	52	16	304	25	20	23	Do.
	18	52	16	304	25	20	23	Clear, faint glow in northern horizon.
	19	52	16	304	25	20	23	Clear, faint glow just over northern horizon at 21^h30^m.
	20	52	16	304	25	..	..	Partly cloudy; faint glow again seen in northern horizon at 21^h to 22^h; clouds thicken later and sky overcast.
	24	52	16	304	25	20	23	Clear, no aurora.
	25	52	16	304	25	20	23	Do.
	28	52	16	304	25	..	..	Clear, faint glow in northern horizon at 19^h30^m disappears at 20^h.
	29	52	16	304	25	..	..	The party left Battle Harbor to return home.

NAVIGATION OF AIRCRAFT BY ASTRONOMICAL METHODS

By J. P. Ault

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NAVIGATION OF AIRCRAFT BY ASTRONOMICAL METHODS.

By J. P. Ault.

INTRODUCTION.

The work discussed in this report was undertaken by the writer during August to December 1918 at Langley Field, Virginia, under instructions from Dr. Louis A. Bauer, Director of the Department of Terrestrial Magnetism, at the request of Lieutenant-Colonel R. A. Millikan, at that time vice-chairman of the National Research Council and in charge of the Division of Science and Research of the Bureau of Aircraft Production. The investigation was under the immediate charge of Doctor Henry Norris Russell, of Princeton University, whose hearty cooperation, encouragement, and assistance are hereby gratefully acknowledged.

This report is supplementary to the one prepared by Doctor Russell and published in *Proceedings of the Astronomical Society of the Pacific*, No. 181, June 1919, to which the reader is referred for details which are not included in the present report.

THE PROBLEM.

The problem confronting the navigator, either at sea or in the air, is to measure the altitude of one or more celestial bodies as accurately as possible and then to compute and plot his most probable position. From this measured altitude a circle of position is determined, the observer being located somewhere on this circle, at any point of which the Sun is at the altitude observed. An approximate knowledge of the azimuth of the object observed will designate the portion of the circle of position on which the observer is located, and usually the circle is so large that a portion 60 to 100 miles long may be considered as a straight line without appreciable error. This line is known as the Sumner line, after Captain Thomas H. Sumner, an American shipmaster who discovered the method which involves the use of this line in navigation. If two celestial bodies are available, two position-lines can be determined, and their intersection completely fixes the geographical position of the observer. If only one object is available, then the observer knows only that he is located somewhere on this position-line, and to completely fix his position it is necessary to observe also the azimuth of the celestial body, or the bearing of some known object on land.

The altitude, usually measured with some form of sextant, is the angular distance of the body above the horizon. For ocean navigation, either on the surface or in the air, the sea-horizon is usually available, but for aircraft flying over land and, at times, over the ocean, some form of artificial horizon must be provided.

After the altitude is measured, the next proceeding is to make the calculations and to draw in the position-line on the chart, or by some method, determine the position of the observer. The usual methods for this work require too much time for aircraft, so that new and rapid methods are necessary.

REPORTS OF WORK DONE AND DISCUSSION OF RESULTS.

The following reports were, except as otherwise noted, submitted by the writer to the Director of the Department of Terrestrial Magnetism from time to time as the work relative to aerial navigation, instruments, and methods at Langley Field progressed. They serve to indicate the methods and instruments used and the results achieved.

REPORT OF SEPTEMBER 10, 1918, FOR THE PERIOD SEPTEMBER 3 TO 10.

On the morning of September 3, 1918, a first flight was made to accustom observer to flight conditions, a sextant being taken for practice work on the natural horizon. Upon returning from this flight, the small atmospheric-electric gimbals taken from the *Carnegie* were fitted with the artificial horizon and counterweight, which Doctor Russell had devised. The counterweight was immersed in heavy cylinder oil and four vanes were provided to increase the damping effect. The mirror used was silvered on the top surface of the glass; the whole mounting was inclosed in a box and protected from the wind. Gimbal and mirror were leveled approximately with spirit level and then more accurately by sighting on some fixed object from a fixed position, with gimbals in different orientations, the weights adjusted so that the measured altitude remained the same, no matter what the orientation.

With the artificial horizon so adjusted, a second flight was made on the afternoon of the same day over a restricted route, and 16 observations were made extending over a period of one-half hour. The mean error of a single observation was ±10′ in altitude.

Some adjustments were made in the bearing surfaces, knife-edges smoothed off, and gimbals approximately leveled again, and a third flight was made on Wednesday afternoon, September 4. During a period of 46 minutes, 49 observations were made, care being taken to get good settings. A mean error of ±12′ in altitude was obtained, rejecting only three shots which were obviously in error, all other shots being less than 35′ in error. Grouping these observations in groups of 5 shots each, the error of any one group was ±20′ in altitude.

The action of the artificial horizon was somewhat erratic at times. Due to some unusual accelerations of the airplane, the horizon would gradually move out of level and remain so for 10 to 20 seconds. Observations made at such times were, of course, in error and could be detected as erroneous by their differing from the average of the main part of the series.

During these three flights Cary sextant 3393 was used without the telescope. Observations were made with ease, no difficulty being found in keeping the images in the field of view at all times for straight flying. The slow-motion screw was used, but this was not sufficiently rapid to keep the images together. The images were superposed, the altitude of the Sun's center being measured, as the vibrations were too great for accurate settings on the limb. The watch was suspended in front of the observer, and the recording pad was placed on a light board resting on the observer's knees. The box containing the artificial horizon rested on the seat beside the observer and was lashed to the fuselage. As the plane changed its direction of flight, the box was shifted from one side to the other. On regular work three mountings should be provided, one on each side and one directly in the rear. The vibration of the engine was not disturbing, nor was the force of the wind felt behind the hood.

On Thursday morning, September 5, a flight was made using the pocket-sextant, Hicks 301, to test its availability for use with the artificial horizon. A map was also taken, and the observations were computed and position determined without previous calculation except that the watch-error was known.

First, five altitudes were measured, of which one was rejected by inspection. The mean of the four was taken, and computation of the altitude-intercept and azimuth was made by use of Aquino's tables.[a] Owing to the large scale of the map, the final plotting of the position could not be done. The longitude error of the position as plotted later was 12′ east or about 8 miles. A second series of seven shots was taken and computed as above. The total time for seven shots was 5 minutes, and the computation and plotting required 5 minutes. The error of the longitude was 29′ west or 20 miles.

[a] Altitude and Azimuth Tables, 1910, by Lieutenant Radler de Aquino, Brazilian Navy.

A third series of ten shots was taken, computed, and plotted in less than 12 minutes, the error of longitude being 3′ west or 1 mile. Thus, the mean error of the three positions determined in the period of 46 minutes was ±10 miles.

With practice and a better artificial horizon a position could be obtained in the air without previous preparation in less than 10 minutes, making at least five shots on the Sun or star. This, of course, presupposes a fair knowledge of the latitude from dead reckoning.

Thursday night, September 5, a flight was made at 21^h30^m to investigate the conditions for navigating at night. The only ship available was controlled from the rear cockpit, so the observer, being in the front cockpit, was limited as to field of view and space. The artificial horizon could not be taken, so a mirror was mounted on each side of the fuselage, and the Keuffel and Esser artificial horizon was mounted on top of the fuselage just behind the observer.

It was found that the pocket-sextant would not be available for night work in its present form on account of the restricted field of view and small peep-sight. The large Hurlimann star sextant was tried and could have been used readily with the proper facilities. Owing to the position of the mirrors and the necessity of leaning out of the cockpit to use them and to see the star, it was not possible to obtain any pointings on account of wind pressure. Polaris was picked up a few times, and observations could have been made on this star.

A flight was made Saturday afternoon, September 7, to make a series of observations on the natural horizon, using pocket-sextant 301. At an altitude of 5,000 to 6,000 feet a fairly good cloud-horizon was visible to the west. The altitude of this cloud-bank was estimated from the scattered clouds passed through on the climb and again on the descent. On this flight one shot was taken about 9 minutes after leaving the ground at a height of 5,200 feet, sighting the lower limb of the Sun. This shot was reduced and the position-line plotted; the resulting longitude as determined by using a dead-reckoned latitude was in error 4′ west. The cloud-horizon was reckoned 4,000 feet in altitude, but was probably slightly less, as the following observations showed. A second shot was taken and plotted, the error in longitude being 5′ west. Two shots were taken for the third position, the error in longitude being 8′ west. Two shots were taken for the fourth position, the error in longitude being 3′ west. These four positions were observed, computed, and plotted in 21 minutes, including time lost between shots. The average time for one complete operation, observation, computation, and plotting was 4.1 minutes.

The mean error was 5′ west. If this error be attributed to error in estimation of altitude of cloud-horizon and removed, the probable error of any one position was 1 to 2 miles, the range in the errors being 3 miles. The only preparation made for this flight was the calculation of the watch-error on Greenwich astronomical time and of the Sun's declination.

Whenever possible a natural horizon should be used, if its height can be determined. The necessity of making a series of observations with the artificial horizon to insure a sufficient degree of accuracy will consume about 5 minutes for the observations on one object and 10 minutes for two objects, so that the determination of a position by the intersection of two Sumner lines, without previous preparation, would require from 15 to 20 minutes. Doctor Russell has outlined a method where the calculations are made previous to a flight, when the objective and time are known. Special tables are prepared and the altitudes and azimuths calculated for different assumed positions and times. This method will give a position-line in 2 minutes of time, including the observation when a natural horizon is used and in 7 minutes when an artificial horizon is used.

All maps used in aerial navigation should be ruled for every 5 minutes of latitude and longitude and marked for rapid plotting of the dead-reckoned and assumed positions.

For the method as used in this work and mentioned previously, based on Aquino's tables, a specially improved celluloid protractor was used, one arm being graduated to tenths of inches. A celluloid protractor 4 inches in diameter, with one arm 8 inches long and graduated to read minutes of latitude for the map to be used, should be provided. This azimuth arm should carry another arm at right angles which could slide back and forth, thus making the setting of the altitude-intercept easy and the drawing in of the position-line possible without the necessity of using another instrument. This protractor would be necessary in laying down a course or route. If this right-angle arm can not readily be made usable and remain always at right angles, a celluloid triangle can be used. Two of these triangles should be furnished, to be used as circumstances require. They will take the place of parallel rulers, dividers, etc. One triangle should be graduated to minutes of latitude to be used to lay off the altitude-intercept for the precalculation method.

It is recommended that the matter of sextants be taken up further and investigated. The Cary type of sextant is quite suitable for day work. No opportunity was had for testing it at night. This will be possible later, when present arrangements are completed. The question of finding the position at night seems to be the one that will offer the most difficulty, owing to the time required to obtain 5 to 10 observations on two or more stars, to insure sufficient accuracy. This may be reduced when a more perfect artificial horizon is made. Work with the present experimental device at night will be undertaken later.

The pocket-sextant was tried at night and did not prove suitable. It is also not suitable for natural-horizon work, particularly when the horizon is dim and hard to distinguish. Any light sextant with good mirrors will be suitable. The frame around the clear part of the horizon-glass should be removed. The index arm should be operated with a rack-and-pinion or similar device to permit of rapid motion and yet remain clamped. Dark shade-glasses should be provided for both mirrors. Such a sextant would be serviceable for both Sun and star work.

With a natural horizon in daylight, a position-line can be obtained from observations on the Sun with all requisite accuracy in less than 4 minutes of time, all work being done in the air. By previous calculation of the altitude and azimuth for various times and positions, the time required to make the observations and to plot the position-line can be reduced to 2 minutes. The observer should always be prepared to work a position-line entirely in the air, as his previous calculation might not always fit the conditions which would develop during the flight.

The tables required for this method can be obtained from the United States Hydrographic Office Publication 200, "Altitude, Azimuth, and Line-of-Position Tables."

It is respectfully recommended that further tests be made with star work by flights at night, that the question of sextants be investigated, that the Department undertake the construction of two artificial horizons as requested and specified by Doctor Russell, and that the instruments and methods be used on actual flights across country and on seaplanes.

Major Simons, commanding officer of Langley Field, as well as Lieutenant T. D. Cope, officer in charge of the Science and Research Laboratory, were extremely interested in the development of the work and in the results obtained, and offered every assistance in their power. Doctor H. N. Russell was exceedingly generous in providing opportunities to make the tests and has already done remarkable work in showing the possibilities of aerial navigation and in making it practicable.

REPORT OF OCTOBER 1, 1918, FOR THE PERIOD SEPTEMBER 16 TO 27.

Eight flights were made during this period, including a flight from Langley Field to Washington and return. Experiments were made using different mirrors, e. g.,

a good piece of glass silvered on the back. It was found that the interference by reflections from the different surfaces was considerable. A speculum mirror should be very satisfactory.

Considerable attention was given the matter of charts and maps. Both the polyconic and the Mercator projections were used. For cross-country flying the Geological Survey state maps, scale 1 to 500,000 or 1 to 1,000,000, could be used, provided the county names and boundary lines and other markings were removed and the map ruled every 5′ of latitude and longitude. The Mercator projection position-plotting sheets issued by the United States Hydrographic Office were used also and probably would be best for ocean work. The Lambert conformal conic projection would have several advantages. Separate local maps can be made and then joined together for an extended trip without any appreciable distortions. Straight lines on this projection are great circles, so that the shortest route between points is easily determined. Distances can be measured in any direction with the same scale. It has no advantage where a wide range in latitude is desired. This projection is being used for the present war maps of Europe.

Some experiments were made with dip measurer 5490. Several flights were made and observations taken with the dip measurer on cloud and haze-horizon. On the four days when the dip measurer was used it was possible to go high enough to get above the clouds and haze and obtain a good straight-line horizon continuous through 360°. Observations for dip of horizon were made before and after altitudes of the Sun and moon were taken. The dip of the cloud-horizon was easily measured on account of the contrast of its color against the sky. The haze-horizon was a sharp dark line away from the Sun, but was very dim near the Sun, hence the dip was not easy to measure.

With an instrument having less magnifying power and with a horizontal scale graduated to 10′ of dip, the dip of horizon could be determined with ease whenever sufficient altitude could be reached to obtain a good sharp horizon. Over land a horizon can be obtained on an average of 90 per cent of the time, according to the testimony of experienced flyers. Over water a good horizon could be obtained more frequently by flying at low altitudes than by flying at high altitudes, since the color of the water merges with that of the sky so often. To use the dip measurer in its present form it was necessary to remove the goggles and observe with the eyes exposed to the wind. This could be done with no serious inconvenience. The error of a single determination of the dip was on the order of ±3′ to ±5′. The mean error of one series on a cloud-horizon of five determinations was −1′, the range being 4′. The height of the top of the cloud-surface was determined by altimeter readings during the ascent and again during the descent, and the altimeter was read when the dip observations were made. The distance between the two horizon images as seen in the instrument was measured on the horizontal scale in the eyepiece instead of the usual method. The value of one division on this scale is 14′ of dip as determined by theodolite observations at Washington on September 14, 1918, by W. J. Peters and J. P. Ault. It was found possible to measure this distance with an accuracy of 0.3 division, the eye being shifted quickly from the reading of one horizon to that of the other.

A natural horizon with its dip determined by means of the dip measurer will add materially to the accuracy of the determination of positions by daylight when there is usually only the Sun visible. A series of fairly accurate position-lines, with the dead-reckoned course and distance run, will give the route of an airplane with all needed precision.

The trip from Langley Field to Washington on Monday, September 23, was made to try out the method based on the use of Aquino's tables, as outlined in my report of September 10, 1918. The pilot had made the flight before and so followed a more or

less straight line between the two places. On the trip to Washington, which occupied two hours in the forenoon, seven position-lines were determined, each based on ten observations of the Sun's altitude, using the preliminary artificial horizon and the pocket-sextant Hicks 301. All the work was done in the air, observations, computations, and plotting of the position-line. No effort was made to race against time. The average time for the observations was 4.5 minutes, for the computations 3 minutes, and for the plotting 2 minutes. On the return trip in the afternoon, which occupied 1 hour and 45 minutes, nine position-lines were determined, the last one not being plotted in the air, as the airplane was descending during the computation. The airplane was quite unsteady during the return trip, sometimes dropping 25 to 50 feet, due to the "bumpy" condition of the air. The pilot was always warned by signal when a series of measurements of the altitude was begun and when it was ended. During the observations he made a special effort to fly in a straight line and with as little change in acceleration as possible.

Table 39 shows the errors in the altitudes for the various position-lines as plotted in the air during the trip.

TABLE 39.—*Altitude-Errors for Position-Lines during Flights on September 23, 1918, from Langley Field, Va., to Washington, D. C. (a. m.), and Return (p. m.).*

Morning flight		Afternoon flight	
Position-line	Altitude-error	Position-line	Altitude-error
	′		′
1	− 5	1	+ 9
2	−22	2	−30
3	+ 2	3	− 1
4	+ 2	4	+15
5	− 8	5	− 7
6	−31	6	−11
7	−24	7	[1] −40
		8	+20
		9	−18
Mean..................	−12	Mean....................	− 7
Mean, regardless of sign...	13	Mean, regardless of sign...	17

[1] Due to one high reading.

The minus sign indicates that the position-line should be moved away from the Sun. With reference to the mean −12′ in the forenoon results and of −7′ in the afternoon results, 7′ of this is due to error in the level of the mirror as determined by observations on the ground made September 24, 1918.

The accuracy is thus seen to be about what was indicated in the first report. A better artificial horizon and a more stabilized plane should improve the accuracy considerably.

A more detailed summary of the results obtained during these flights is given in Table 40. (See Fig. 9.)

A flight was made at night, using the artificial horizon and Keuffel and Esser hydrographic sextant with telescope. Conditions were not of the best for such work on account of the necessity of remaining within gliding distance of the field. Observations were made on Polaris, ten shots being obtained in 4.2 minutes with the same degree of accuracy as had been obtained by observations on the Sun and in the same time, the resulting latitude being in error only 4′. Other stars were picked up and altitudes measured to determine the practicability of night work. The series of observations on Polaris was sufficient to show the practicability of night work, the time required and

the accuracy obtained being the same as for Sun work. A telescope is necessary to assist in picking up the reflection in the mirror. The vibration of the engine enlarges the reflection in the mirror and is an added assistance.

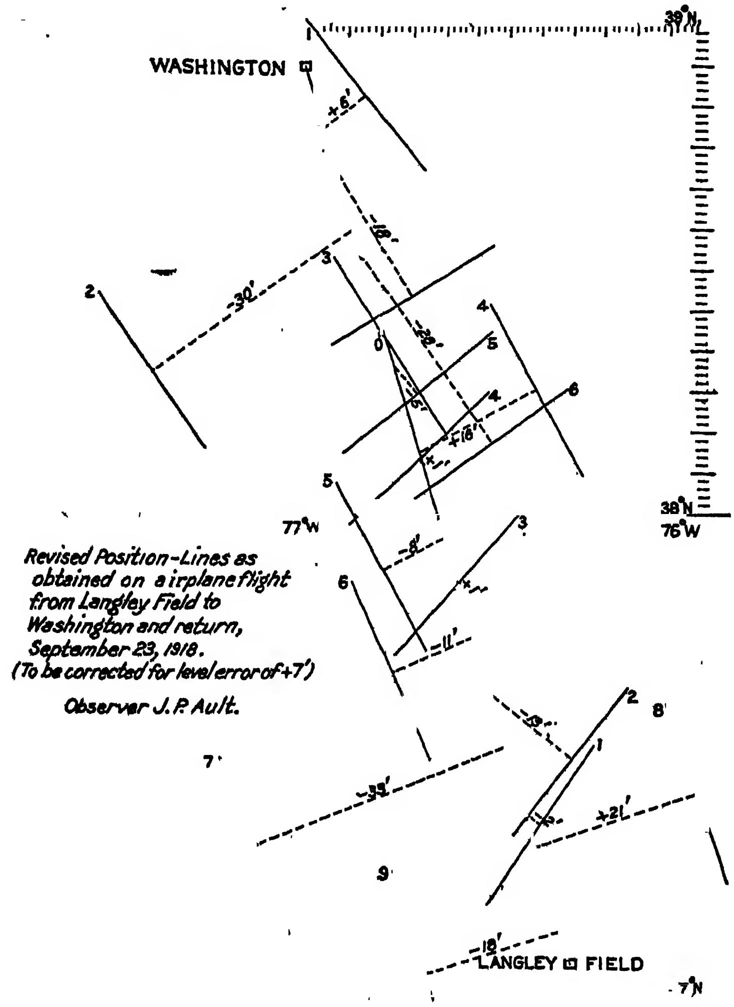


FIG. 9.—Revised Position-Lines, Airplane Flight from Langley Field to Washington and Return, September 23, 1918.

The pocket-type sextant has been found best for artificial-horizon work on the Sun on account of small size, allowing very near approach to the mirror, which is especially desirable for low altitudes, ease of handling, protection of glasses, etc. A light-weight sextant of size similar to Keuffel and Esser hydrographic pattern, with a rapid-motion tangent-screw device, will be best for natural-horizon work by daylight and for star work at night, and can be used readily for artificial-horizon work on the Sun. It will be best to adopt one type of sextant for all the observations. A dip measurer, modified as suggested above, should be provided. A celluloid protractor, as specified in my report of September 10, 1918, will be required.

Existing charts and maps may be adapted for cross-country flying and for trans-oceanic trips, but special maps should be provided showing only the main topographical features that would be of use in identifying a locality from the air. This question should

be taken up with an experienced cartographer or some organization such as the United States Geological Survey, the United States Coast and Geodetic Survey, or the United States Hydrographic Office, and a suitable map adopted and a special mounting designed. A padded case should be provided for the sextant and padded supports for the chart table or board to take up the vibration from the engine.

TABLE 40.—*Summary of Results of Observations Taken during Flights on September 23, 1918, from Langley Field, Va., to Washington, D. C. (a. m.), and Return (p. m.).*

MORNING FLIGHT.

Position line No.	Number of obs'ns	Elevation	Compass course	Watch time	Observed double altitude	Range in double altitude	Altitude-intercept	Computed azimuth	Error in altitude: Original computation in air	Error in altitude: After revision	Error of probable position off line of flight
		feet	°	*h m*	° ′	° ′	′	°	′	′	*miles*
1	10	4,200	360	9 38	73 30	3 30	− 2	55.8	+ 2	+ 5	−10
2	10	4,000	88	9 54	78 43	5 22	− 1	51.9	−15	− 6	−13
3	10	4,100	350	10 08	81 54	4 29	−14	48.0	+ 9	+ 8	0
4	10	4,000	345	10 25	86 13	3 22	+ 2	43.2	+ 9	+ 8	− 3
5	10	4,200	340	10 39	89 36	1 45	− 6	39.0	− 1	+ 2	− 1
6	6	5,000	340	10 53	93 21	1 04	+ 8	34.6	−24	−21	− 8
7	10	4,000	10	11 04	94 55	2 27	+17	31.0	−17	−11	− 9
	Means								− 5	− 2	− 6
	Probable errors								±11	± 9	....

AFTERNOON FLIGHT.

Position line No.	Number of obs'ns	Elevation	Compass course	Watch time	Observed double altitude	Range in double altitude	Altitude-intercept	Computed azimuth	Error in altitude: Original computation in air	Error in altitude: After revision	Error of probable position off line of flight
		feet	°	*h m*	° ′	° ′	′	°	′	′	*miles*
1	10	4,000	170	15 03	73 57	2 16	+ 4	52.6	+16	+13	+ 7
2	10	4,900	160	15 14	71 51	3 12	+ 1	55.6	−23	−23	−22
3	10	4,400	175	15 26	67 02	3 59	+12	58.6	+ 6	+ 7	+ 1
4	10	4,000	170	15 39	62 18	5 02	− 8	61.1	+22	+23	+ 5
5	10	4,100	190	15 51	59 04	3 07	+ 6	63.9	0	− 1	− 4
6	10	4,000	190	16 03	54 48	3 39	+ 5	67.2	− 4	− 4	− 2
7	10	4,850	190	16 15	51 35	5 10	+20	69.0	−33	−26	−20
8	5	....	....	16 27	45 02	0 56	−10	71.4	+27	+28	+11
9	10	3,800	150	16 37	42 21	4 45	+ 7	73.4	−11	−11	−12
	Means								0	+ 1	− 3
	Probable errors								±17	±15	....

It is recommended (1) that a trip to New York be made to investigate further the question of sextants, with special reference to the Keuffel and Esser type of sextant, price, and possibility of construction in quantity, and (2) that a model celluloid protractor be made by the Department, in accordance with suggestions made in the first report, for experimental use and to serve as a pattern for construction.

I again wish to express my thanks to Major Simons and to Lieutenant Cope for their interest and hearty cooperation.

REPORT OF NOVEMBER 12, 1918, ON DETERMINATION OF DEVIATIONS OF AIRPLANE COMPASSES DURING FLIGHTS.

Special instruments will be required for the determination of deviations of airplane compasses. The compasses are now mounted on the instrument board directly in front of the pilot or observer and underneath the cowl of the fuselage. This will necessitate the use of some sort of sighting device entirely separate from the compass, to be mounted on the fuselage, where an uninterrupted view of objects or landmarks may be had for as large a horizontal angle as possible.

This sighting device may consist of (1) vertical wires attached to the airplane in front of the pilot or observer and in the fore-and-aft line of the airplane, so that the airplane may be steered on some definite bearing, or (2) a pelorus or some azimuth sighting device, properly oriented with reference to the fore-and-aft line of the airplane, and fixed level with the level-flying position of the airplane. This sighting device could be mounted on gimbals, as is being done for artificial-horizon work, so that bearings of the Sun, moon, or stars could be taken. The following methods are suggested:

(*a*) Steer the airplane on different headings over a fixed point, and when immediately over the point observe the compass bearing of some distant object whose magnetic bearing from the fixed point is known. The difference between the observed compass bearing and the magnetic bearing of the distant object is the compass deviation. If the pelorus is not mounted on gimbals or other device to maintain the instrument in an approximately level position, the airplane must be steered to fly as level and straight as possible over the fixed point when the bearings are being taken.

(*b*) Pick out a number of prominent objects, visible and of known magnetic azimuth from some fixed point, then steer the airplane over the fixed point in the direction of each prominent object in turn by means of the vertical sighting wires. The difference between the various compass courses steered and the magnetic bearings of the prominent objects will give the compass deviations for the various headings. The deviations for the other headings can be determined by drawing a curve through these observed deviations after plotting them.

(*c*) A method similar to the foregoing may be used during night flights. Properly selected and well-known stars may be used as the prominent objects. The magnetic bearings of these stars may be computed by noting the time when each star is sighted, computing the true bearing by use of azimuth tables, and properly applying the magnetic declination.

(*d*) With an azimuth circle or pelorus mounted on gimbals or other device for maintaining the instrument in a level position, compass bearings of the Sun, moon, or stars may be obtained. The compass deviations are determined as indicated above.

(*e*) If the direction and speed of the wind at the level on which the airplane is to fly are known or can be determined by the use of a meteorological kite, the following method might be used: On the ground two theodolites are mounted and leveled, one at each end of a base-line of known length and bearing. The observer at each theodolite keeps the instrument pointed on the airplane as it flies back and forth over the field, following certain fixed compass courses or going through the regular "swinging ship" operation. Shortly after the airplane steadies on one heading, the pilot sends a signal by wireless or other method to the observers at the theodolites and they immediately read the horizontal circles of their instruments. Then they resume pointing at the airplane until the pilot sends another signal just prior to turning to another course, when the observers again read the horizontal circles. This operation is repeated for as many courses as desired. The theodolite bearings thus taken are plotted on a properly oriented map, and the intersection of two simultaneous bearings determines one position of the airplane. A line connecting two points thus determined represents the path over the ground followed by the airplane between the signals on one course. Knowing the direction and speed of the wind and the local magnetic declination, this line can be corrected to represent the magnetic heading of the airplane and this heading compared with the compass course steered gives the compass deviation.

REPORT OF NOVEMBER 13, 1918, OF PROGRESS SINCE OCTOBER 1 IN DEVELOPING ASTRONOMICAL METHODS AND INSTRUMENTS FOR DETERMINING GEOGRAPHIC POSITIONS OF AIRPLANES ON LONG FLIGHTS.

This report may be subdivided under the headings of charts, instruments, and methods.

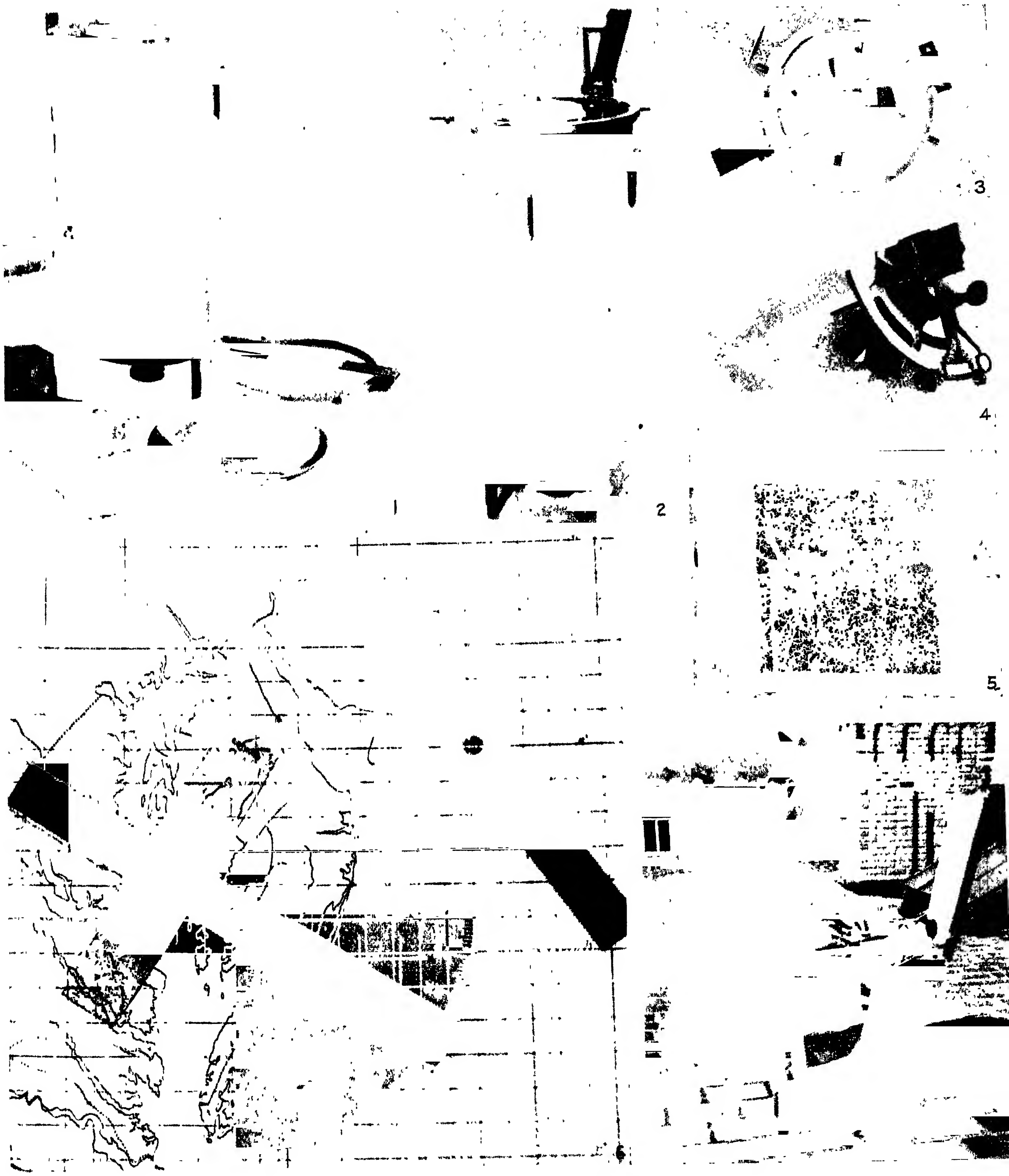
Charts.—A chart was made up on Lambert's conformal conic projection, scale 1/1,000,000, extending in latitude from 36° 30′ north to 41° 30′ north and in longitude from 72° west to 82° west, inclusive. Various position-lines were drawn on the chart and its adaptibility was tested in various ways. It was found to meet the requirements of the problem in every respect. On this projection the meridians are all straight lines so that azimuths may be laid off from any assumed point. The altitude-intercepts are always measured on the arc of a great circle. This is practically a straight line on the Lambert projection, so that the altitude-intercept may be very large, without any appreciable distortion or divergence from the true arc of a great circle. This will be especially valuable in the precalculation method where an ephemeris need be computed for the object to be observed for only one assumed position in the region to be traversed. This idea is worked out and tables given in an article by Mr. G. W. Littlehales in the United States Naval Institute Proceedings, March 1918.

It is suggested that charts on the Lambert conformal conic projection be made up to cover some particular route, on a scale of 1/200,000 or 1/500,000, for use in cross-country flying, to be mounted and carried on rolls and each roll to cover a strip 50 miles wide and a maximum of 1,000 miles in length. Thus, some trips would require more than one roll. A map on this scale, with objects specially marked which would assist an airplane pilot in locating his position, would be required for cross-country flying, to be used merely as a guide, not being serviceable for the plotting of the position-lines. The existing polyconic maps issued by the United States Geological Survey might also be adapted to this use as cross-country guides. Maps made up from photographs would be the best guides.

Maps made up on the scale 1/1,000,000, ruled every 10′ of latitude and longitude, would be required for position-line plotting. Sheets should be made of uniform size, depending on the space available in the navigator's cockpit and numbered according to some scheme so that a map for any particular region might be located immediately. Such maps can be filed as separate sheets or mounted on rollers and cut to cover any particular route.

Instruments.—A special protractor (see Pl. 14, Fig. 6) was designed and made for plotting position-lines. It consists of a celluloid quadrant graduated to degrees, on which is pivoted an arm for setting off the azimuths. This azimuth arm is graduated to minutes of arc corresponding to the scale of the chart used. A second arm slides back and forth on the azimuth arm and at right angles to it. Position-lines may be plotted very rapidly with this device, especially if the chart is ruled every 10′ of latitude and longitude, which should always be done on aerial charts to facilitate the plotting of positions. It will not be necessary to rule every 5′ of latitude and longitude, as suggested in former reports.

Owing to the uncertainties of "dead reckoning" during airplane flights over the ocean or above the clouds, where there is no means at present to determine the amount of drift, it may be of value to obtain the azimuth of the body observed as well as the altitude. For this purpose a simple pelorus or azimuth sighting-device was mounted on the artificial horizon. It is seen from the trigonometrical conditions and from Aquino's tables that if the altitude and azimuth can both be measured with a fair degree of accuracy, then the navigator need not know his "dead-reckoned" position at all, except to determine his magnetic declination. If Aquino's tables are used, no assumption need be made regarding a dead-reckoned position to obtain the most probable



NEW INSTRUMENTS FOR AERIAL NAVIGATION.

1. Artificial horizon, with mounting block, cover, and azimuth circle.
2. Artificial horizon with azimuth circle in place.
6. New protractor for plotting Sumner lines, with extra azimuth and altitude-intercept arm.
3. Top view of artificial horizon, showing speculum-met mirror.
4. Patrol-boat-type sextant, with 5-inch arc.
5. Navigating board and chart case closed, showing chart.
7. Navigating board and chart case in position on observe knees.

position, since the tables can be entered with the observed altitude and azimuth to determine a value of the auxiliary a. Entering the tables with this a will give the hour-angle, and thus the most probable longitude may be determined. By so choosing the auxiliary C that the altitude-intercept is zero, the most probable value of the latitude is obtained.

Thus, an assumed position is obtained which coincides with the most probable position of the airplane as based on the observed altitude and azimuth. By plotting these assumed positions the route followed by the airplane is shown much more closely, where observations can be made on but one object such as the Sun, than by depending on the position-line alone, as based solely upon the measurement of the altitude. The extension of Aquino's tables as suggested by him would furnish a ready means of calculating the assumed position, or, in this case, the most probable position, directly and without interpolation. It is, of course, recognized that the problem of obtaining bearings of celestial objects from moving airplanes is a complicated one, and that there are limiting conditions where the method fails. It is proposed to investigate the problem at Langley Field to determine what degree of accuracy can be obtained in observing azimuths from rapidly moving airplanes.

Upon visiting the United States Naval Observatory, Professor Charles Lane Poor's line-of-position computer was seen. By request, Professor Poor kindly loaned the Department one of these instruments for experimental use. The instrument is designed to solve mechanically the problem of determining the longitude from time sights, or the altitude and azimuth in accordance with the Saint Hilaire method. It is essentially a circular slide-rule, and a few simple settings with the jotting down of only one figure represents the operations required. After solving 15 different examples, the altitude and azimuth could both be computed with this instrument in the time of 1.1 minutes. The instrument seems well adapted for airplane use, being simple, avoiding troublesome precepts, requiring no turning of pages and practically no writing down of figures. This instrument can be used also to determine the hour-angle if the altitude and azimuth are both measured. This would give the most probable longitude, and the intersection of the position-line with this meridian of longitude would give the most probable position of the airplane.

At the United States Naval Observatory a small patrol-boat-type sextant (see Pl. 14, Fig. 4) was inspected. This sextant had just been completed for the Navy Department by Brandis and Sons, Brooklyn, and it appeared that it could very easily be adapted for airplane use. The arc has a radius of 5 inches and is graduated to half degrees up to 180. The loan of this instrument has been obtained from the Navy Department for experimental use in airplanes. It is understood, if the instrument is found satisfactory, that there are 150 of the same type being completed which can be turned over to the Army at once.

An effort is being made to secure a sextant with artificial level for experimental use. If such an instrument gives as good results as can be obtained with the artificial-horizon method, it will be much more generally useful and cheaper to produce. This type of instrument has been used successfully in balloon work. If such an instrument can not be found ready to use, it is respectfully recommended that an artificial level be made by the Department to be attached to one of our standard sextants.

To provide a container for the charts, protractor, books, etc., to be used during the experimental work on airplanes, a special navigation box (see Pl. 14, Figs. 5 and 7), was designed and made by the Department. It is designed to carry a roll-chart, on scale 1/200,000 or 1/500,000, to be used as a guide on cross-country or coast flying, several charts on the scale 1/1,000,000 on which the position-lines are to be plotted, and the line-of-position computer, besides having mountings for protractor, almanac,

records, etc. The box is to be strapped to the observer's knees and, when closed, shows through a celluloid top the guide chart, which can be rolled up as the airplane moves across the country. When it is desired to compute or to plot a position-line, this top is raised up like a desk top, revealing another board upon which is mounted the charts in separate sheets for plotting the position-lines. This board in turn, when raised, reveals the line-of-position computer in the bottom, with the protractor, pencils, almanac, and record pad mounted on the under side of the board carrying the plotting sheets. It is essentially a chart table, instrument case, and computing desk combined.

A special record form (see below for specimen) was made upon which space was provided for recording the observations of ten watch times and ten altitudes, for computing the chronometer correction, the declination, the right ascension or the equation of time, the altitude correction, the Greenwich hour-angle, and the altitude and azimuth by Aquino's method.

Methods.—The precalculation method has been given considerable attention. This method can be made very rapid and practical by some modifications of the scheme outlined in Mr. Littlehales' paper mentioned above. If the region to be traversed is limited in extent, tables giving the altitude and azimuth according to the hour-angle and declination for the Sun, moon, and planets can be computed and printed and will

GEOGRAPHIC POSITION IN AIR: POSITION-LINE OBSERVATIONS.

Flight: Langley Field, Va., to Washington, D. C.
Aircraft: JN6HO No. 41848 *Date:* Mon., Sep. 23, 1918
Observer: J. P. A. *Chron'r:* 254 *Sextant:* 301

Object	Chron'r time h	m	s	Obs'd altitude[1] °	′
Sun's center	9	35	40	72	35
		36	15	74	06
		36	40	73	26
		37	25	72	20
		37	44	72	49
		38	35	75	50
		39	10	74	08
		39	30	73	56
		39	50	73	21
		40	15	72	26
Means	9	38	06	73	29.7
Corr'ns	+ 4	34	46		−06
G. M. T.	2	12	52	73	24
Eq. time		+ 7	26		

Chronometer comparison	h	m	s
Chronometer 1128	6	19	00.0
Correction	+ 4	51	11.4
G. M. T.	11	10	11.4
Chronometer 254	6	35	25.6
Correction	+ 4	34	46

Corrections to obs'd altitude

Height of eye: 0.0 feet
Horizontal parallax: 0.0

Index correction	−5′
R. & P.	−1
Dip	0
Total	−6

Object			
Accel	For star obs'ns		
R. A. M. S			
G. S. T.			
R. A.			
G. H. A.	2	20	18

Astronomic elements

	Declination		R. A. or Eq. T.	
At 2.0 hours	+ 0°	06′.6	+ 7^m	260
Hourly diff		−01.0		+00.9
Number hours		+00.2		+00.2
Correction		−00.2		+00.2
At observation	+ 0	06	+ 7	26

	°	′
Arc	35	04.5
λ_{DR}	76	28
t_{DR}	41	24
ϕ_{DR}	37	23
a	41	30
h_o	36	42
h_c	36	44
Diff		−02
Z	S55°.8E	

Arc	35	04.5	
t_A	41	30	Assumed position.
λ_A	76	34.5	Assumed position.
ϕ_A	37	09	Assumed position.
b	0	09	
C	37	00	

Remarks

Horizon: Artificial. Altimeter: 4,200 feet.
Thermometer reads: 15° C. Direction of object: SE.
Compass reading: 360°.
a, *b*, and *C* are auxiliary quantities from Aquino's tables.

[1] Double altitude observed, using artificial horizon.

always be available for that region and for the one assumed latitude. The longitude may have any value. A protractor circle can be printed on each sheet, so that the altitude-intercept and the azimuth can be laid off by inspection. If the region concerned is rather extended, then two or more latitudes can be adopted, tables calculated for these latitudes, and charts made up accordingly. With tables of proportional parts the necessary interpolations can be made very readily. For fixed stars, whose declinations change very little during the year, the time interpolation would be the only one required and the method should prove very rapid.

The method outlined in Aquino's tables published by the United States Hydrographic Office in their Publication 200, "Altitude, Azimuth, and Line-of-Position Tables," has been the only one used by the writer thus far in actual flights. After all preliminary calculations have been made and all the work done that is necessary, no matter what the method, the time required to compute the altitude and the azimuth by this method has been about 2.5 minutes. This method has the advantage that no previous knowledge of the dead-reckoned position is necessary if both the altitude and the azimuth of the observed body be measured with a fair degree of precision. On the large airplanes and seaplanes it should be possible to determine azimuths fairly accurately by providing a place for the navigator and his compass as far removed from the engines and steel or iron parts as is practicable, and above the planes, so that he may have an unobstructed view of the horizon. The extended tables already suggested by Aquino in his "The Newest Navigation Altitude and Azimuth Tables," 1912, Appendix I, would be a decided improvement in eliminating tedious interpolations. His present tables are immediately available and are "the simplest and readiest" and the most rapid of any tables used for the solution of the problem.

So far the only mechanical method considered has been the one due to Professor Poor, who solves the problem with his line-of-position computer, which has been described above. Of the three methods considered, the one based upon the use of this instrument promises to be the best, the simplest, and the most easily learned, the most rapid and the most convenient of operation during flights. After the preliminary calculations necessary to any method are made, only one figure need be written down, and the operation of the instrument may be done with the hands in gloves. This instrument will be given a thorough trial during the next visit to Langley Field.

REPORT OF NOVEMBER 18, 1918.

In accordance with the experience gained by the compass men at Langley Field under the direction of Major C. E. Mendenhall, the determination of the Sun's azimuth seems very hopeful of accomplishment with a very fair degree of precision. It will be necessary, however, to have the pelorus mounted on gimbals. As the mounting for the artificial horizon must be non-rigid to avoid vibration interference on the larger airplanes, the relation of the pelorus to the level flying position of the airplane can not be determined with sufficient accuracy, nor can it be maintained.

The most successful azimuth device used so far has been the center-vertical-pin-shadow device (one of the Kelvin compass methods). This avoids the necessity of having a movable pelorus, and the level of the gimbals is not disturbed. The shadow is always there to be read on the instant. The compass is watched until it becomes steady, then it is read and the eye quickly shifted to the shadow of the pin.

Some of the results obtained have been very promising, one series of 40 readings ranging only 3° in the differences. By grouping another series of 40 readings in groups of ten, the mean errors by groups were $-2^\circ\!.4$, $0^\circ\!.0$, $+0^\circ\!.2$, and $-0^\circ\!.8$. The average time required for ten readings was two minutes. These observations were made on a De Haviland fighting airplane, uncompensated compass with deviation of ±25°. This

certainly looks very promising as a great aid to the aerial navigator during daylight travel when only the Sun is visible.

It has been found that the deviations of the compass (see Fig. 10) as determined under flying conditions in the air differ very little from those determined on the ground. This applies to the compass in the rear cockpit. The compass has moved over 10° at times while the shadow of the pin remained the same. This work with shadow of pin has all been done by Messrs. Sterling and Hoover with the gimbals of our special atmospheric-electric stand, or the preliminary artificial-horizon mounting.

It is respectfully requested that a simple graduated circle be made to fit on the cross-bars supporting the mirror of artificial horizon No. 2 (see Pl. 14, Figs. 1, 2, and 3), with center pin supported from above by cross-piece supported on two vertical standards attached to the ring. The length of the pin should be equal to the radius of the ring for the present experimental work so as to provide for altitudes up to 45°. The vertical standards, cross-piece, and pin should be as light as will be consistent with strength. Mr. Fleming may be able to devise a better scheme for mounting the vertical pin so as to offer as little interference as possible to altitude measurements.

The scheme that should be carried out ultimately is to have the navigator's compass and bowl mounted on ball-bearing gimbals with the mirror in the center of the glass cover to the bowl, leaving space for the compass-card graduations to be seen around the mirror. A center pin could easily be mounted over the center of the bowl for azimuth work. This instrument should then be mounted on a stand or binnacle in the center of the cockpit, with the observer's seat arranged to revolve around the stand.

Report of December 10, 1918, Covering the Periods November 16 to 21 and November 25 to December 6.

As indicated in my report dated November 13, 1918, the problem of the determination of the Sun's azimuth from an airplane was to be considered during this visit to Langley Field. The first few days were spent in conferring with Doctor Russell and with Mr. A. Sterling, who, under the direction of Major Mendenhall, has been making some investigations into the behavior of different compasses. Some flights were made to observe the action of the compass under normal straight flights as also during steep-banked turns. Some results obtained by Mr. Sterling were studied and a flight was made on November 21, 1918, during which 80 observations of the Sun's bearing were made. A card, graduated to half degrees from 0° to 360°, was mounted on the preliminary artificial-horizon mounting consisting of the gimbal-rings of the atmospheric-electric stand formerly used on the *Carnegie*. A vertical pin was mounted in the center of this card, and the Sun's bearing was determined by noting the card-reading of the shadow of the pin, reading simultaneously the magnetic heading of the airplane by the compass mounted near the pelorus. The relation between the 0–180° line of the pelorus card and the lubber-line or fore-and-aft line of the compass was determined when the airplane was "swung" on the ground to determine the deviations of the compass on the different headings. The compass used on this occasion was a flat-card type made up after specifications by Creagh-Osborne of England.

The 80 observations obtained were arranged in eight groups of 10 each. The deviations thus obtained were plotted alongside the deviation curve as determined when the ship was "swung" on the ground. They seemed to indicate a deviation curve slightly different in position but exactly similar in character to the deviation curve as determined on the ground. Observations on only two general headings could be obtained, so that a complete determination of the deviations could not be made.

These results looked so promising that it was decided to return to Washington and have a pelorus made up to fit on the gimbals of the new artificial horizon. This was done, and, as a few days would elapse before this pelorus could be completed, I returned to Langley Field and resumed experiments with the preliminary pelorus previously used.

On November 25, 1918, a flight was made with the preliminary pelorus, but having the large Navy compass XVI-7 mounted on the airplane. During this flight nearly 120 observations of the Sun's azimuth were made on three different headings. The probable error of the mean of any 10 observations was $\pm 0.^\circ 6$, and the mean difference between the deviations as determined in the air and those determined on the ground was $\pm 0.^\circ 1$. Only 2 of the 12 groups were in error over 1°, the average error for the 10 groups being $0.^\circ 3$. These results show that most excellent azimuths can be obtained with an airplane compass. Thus aerial navigation by daylight will be a much more certain proposition by measuring both the altitude and azimuth of the Sun rather than by measuring the altitude only.

On November 26 I was invited by Lieutenant Cleary to be the navigator on a cross-country flight from Langley Field to Columbia, South Carolina, and return. He was to command and lead a group of five airplanes on this flight, and, as both Doctor Russell and I considered it a good opportunity to obtain some experience in actual navigating in the air, it was decided that I should go. In order not to delay the tests with the new pelorus when completed, and as it was desirable to take with me artificial horizon No. 2, it was requested that Mr. Fleming bring artificial horizon No. 3 to Langley Field and do some experimental work with the pelorus during my absence. He has made a separate report of the results of his experiments (see pp. 332–335).

During this flight of 350 miles and return, the attempt was made to follow straight-line courses from point to point by means of the compass. Geological Survey maps, scale 1/500,000, were used in the special navigation case, and the drift was determined and allowed for by checking on various easily identified landmarks of the country traversed. Our position was always known to within 5 miles and usually to within 1 mile. None of the party had been over the route before, and the navigation was all done by map and compass. All of the airplanes had been "swung" before our departure, and the deviations of all compasses were posted on the instrument board in front of each pilot and observer. The magnetic bearing of the next point was given each pilot, and when the wind's direction and force were known, as at Columbia, the amount of drift was calculated and the corrected course was given. At times the magnetic bearing and the course actually steered differed by 50°, due to a heavy wind, and at other times the drift was negligible. Table 41 gives an abstract of log for the trip.

TABLE 41.—*Abstract of Log for Airplane Flight from Langley Field, Virginia, to Columbia, South Carolina, and Return, November 27 to December 6, 1918.*

Date	Place	Leave	Place	Arrive	Magnetic bearing	Course steered	Distance	Time	Rate per hour
1918		*h m*		*h m*	°	° °	*miles*	*min.*	*miles*
Nov 27	Langley Field...	11 09	Franklin.......	11 50	231	231 to 270	46	41	67
27	Franklin.......	15 27	Raleigh........	17 04	240	250 to 225	110	97	68
30	Raleigh........	11 51	Pinehurst......	13 05	230	230 to 270	65	74	53
Dec 3	Pinehurst......	9 38	Columbia.......	11 28	229	250 to 220	121	110	66
5	Columbia......	9 21	Pinehurst......	10 57	49	30 to 15 to 30	121	96	76
5	Pinehurst......	13 28	Raleigh........	14 13	50	40 to 30	65	45	86
6	Raleigh........	9 55	Franklin.......	11 25	60	10 to 40	110	90	73
6	Franklin.......	13 40	Langley Field...	14 12	51	20	46	32	86

The delays were due to bad weather, poor gasoline, and minor repairs to airplanes and motors.

The trip was instructive in showing that for cross-country work a good map and a compass whose deviations are known are all that are required. Constant attention is necessary to correct for changing winds and consequent change in drift.

As indicated in my letter of November 18, 1918, an ideal instrument for aerial navigation would be an improved compass and bowl mounted on ball-bearing gim-

bals, with the mirror of the artificial horizon mounted in the center of the glass cover of the bowl, leaving space for the compass-card graduations to be seen around the mirror. A vertical pin should be mounted above the center of the bowl for azimuth work, the shadow of the pin to be read directly on the compass-card. This instrument should then be mounted on a stand in the center of the navigator's cockpit, well removed from the engine and other sources of magnetic disturbance, if possible, and the navigator's seat should be arranged to revolve around the stand. Thus observations of altitude and azimuth could be made on any object, no matter what its bearing, without the necessity for a change of heading. The suggestion to mount the artificial-horizon mirror on the compass bowl is due to Doctor Russell.

There will be times when the artificial horizon can not be used at all, due to unusual atmospheric conditions, as when the air is very "bumpy." This was the condition during the return trip from Columbia when the airplane was continually tossed about, once or twice dropping so suddenly that the pilot and observer would have been thrown out had their belts been unfastened.

The first known instance of an airplane pilot being informed of his position by astronomical methods should be recorded here. During my flight to Washington from Langley Field September 23, 1918, the visibility was very poor. The pilot, Lieutenant Charles Cleary, wished to verify his position, so he slowed down and asked if the river below us was the Potomac. I had just completed drawing in position-line No. 5 (see my report of October 1, 1918), which intersected our track at the Potomac River, so I was able to inform him that my observations placed us at the Potomac River.

In conclusion, it may be well to indicate other methods which offer possibilities for improved accuracy over the present artificial horizon. (1) The sextant with artificial level should by all means be tried. (2) The officers in charge of developing bomb-sights at Langley Field have developed a small gyroscopic top which gives much promise. A mirror could be mounted on such a device and would never vary more than 1° from the horizontal for straight flying, if present indications are trustworthy. (3) Large airplanes, carrying their own wireless outfits, might be navigated by wireless from two land stations or from two vessels at sea, as has been done in the case of the Zeppelins, if report is correct. It is also reported that bombing airplanes have been navigated by the pilot keeping the airplane in the directional line of intensive wireless sending from one wireless station. With the methods and instruments at present developed at Langley Field, the aerial navigator should be able to determine his position every 20 minutes during the day or night, except during twilight and when the Sun is near the meridian or the prime vertical, with a maximum error of 30 to 60 miles by day, when only the Sun is available, and of 15 miles by night, when two or more stars are available.

REPORT OF DECEMBER 11, 1918, BY J. A. FLEMING, ON EXPERIMENTAL WORK AT LANGLEY FIELD DURING NOVEMBER 27 TO 30.

By courtesy of the officer-in-charge and of Captain T. D. Cope, in charge of the Science and Research Laboratory at Langley Field, I had the privilege of making experimental observations during a flight in airplane 41948 (Curtiss type) on each of three days, viz, November 27, 29, and 30.

The observations on November 27 were made with the experimental shadow-pin device with gimbal mounting and Sperry aircraft compass XVI-7 previously used by Private A. Sterling for experiments of the National Research Council. The former consisted of a bristol-board circle about 19 cm. in diameter graduated every half degree in an anti-clockwise direction suitably mounted on the gimbal-rings of the small gimbal-stand loaned by the Department. These rings were in turn supported in a wooden box, so that the instrument was high enough when in place in the airplane to permit observation of the circle-reading of the shadow of a pin about 3 mm. in diameter pro-

jecting through the center of, and perpendicular to, the graduated circle. The direction of the Sun could thus be referred to simultaneous compass-readings. Eleven sets of observations were made on practically six different courses, a single set consisting of 10 readings of the compass and 10 readings of the shadow made alternately as rapidly as possible; a set required from one to one and one-half minutes. The least graduation of the compass-card is five degrees; single degrees were estimated. The instruments were mounted on a board in front of the observer's seat, the compass to starboard and the shadow-pin to port, the distance between centers being 21 cm., with the top of the compass about 15 cm. below the shadow-pin circle. There were no special precautions taken to eliminate effect of vibration caused by the engine.

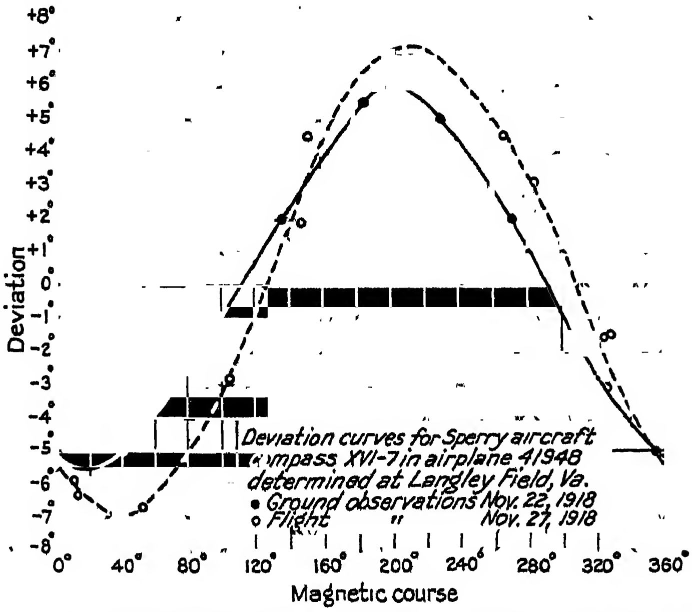


FIG. 10.—Compass Deviation-Curves for Airplane, on the Ground and in Flight.

On November 29 and 30 the experimental shadow-pin device was replaced by Doctor H. N. Russell's artificial horizon, upon which was mounted a graduated brass circle with shadow-pin made in the Department's workshop. The circle was carried by the arms supporting the horizon-mirror, thus becoming a part of the gimbal system of the horizon. The horizon was supported by a sponge-rubber ring 2 inches thick and about three-quarters of an inch wide fitting snugly around the horizon-case and mounted in a brass ring, which was free of the case, on a wooden box similar to that used for the first day's work; this arrangement appeared to eliminate vibration effects to a great extent, although these caused little trouble on November 27, when the heavier gimbal-mounting was used. The compass was mounted as in the first day's work; its action would probably have been improved somewhat had it been similarly supported by a rubber pad. The deviations for the compass were considerably changed, because of the magnetic materials in the bearings of the artificial horizon, from those on November 27; there was no opportunity to make deviation determinations on the ground. The conditions on November 29 were only moderately good, while on November 30 clouds interfered somewhat and the work had to be hurried because of the half holiday and a late start occasioned by the use of the horizon in another test. The 20 sets obtained on the two flights were limited practically to four courses. The results and conclusions may be summarized as follows:

(*a*) Graphs of the results obtained are given in Figures 10 and 11. It is to be noted that, in general, very good agreements were obtained from observations made on the same or approximately the same course at different times during a flight. The deviation coefficients as defined by the formula

$$\text{Deviation} - A = B \sin \zeta + C \cos \zeta + D \sin 2\zeta + E \cos 2\zeta$$

where ζ is the ship's magnetic course determined from the data obtained, are shown in Table 42.

TABLE 42.—*Deviation Coefficients for Sperry Aircraft Compass XVI-7 in Curtiss Airplane 41948, from Flight Observations at Langley Field, Virginia.*

Date	B	C	D	E	Prob. error [1]	Pilot	Altitude	Remarks
1918	°	°	°	°	°		*feet*	
Nov 22	−2.1	−5.1	+0.2	+0.1	±0.1	....	0	From A. Sterling's observations.
27	−4.2	−5.7	0.0	+0.2	±0.4	Lt. R. H. Mueller...	5200–6300	Instruments and set-up as Nov. 22.
29	−3.3	+3.5	−1.4	+0.6	±0.4	Lt. E. W. Hawkins..	3000–4000	Compass as Nov. 27, but new shadow pin with magnetic material causing changes in deviations.
30	−3.4	+4.6	−1.6	+0.4	±0.7	Lt. E. W. Hawkins..	5600–6900	

[1] Probable error, single observation, $r = \pm 0.337 \sqrt{\Sigma v^2}$ for eight points.

(*b*) There was no difficulty experienced in observing, except for the interference of the wings of the plane, which prevented taking observations upon some courses. It would probably be feasible to mount a shadow-pin device in gimbals a short distance above the upper plane, using a transparent graduated circle, the readings of the shadow being made below by means of a mirror.

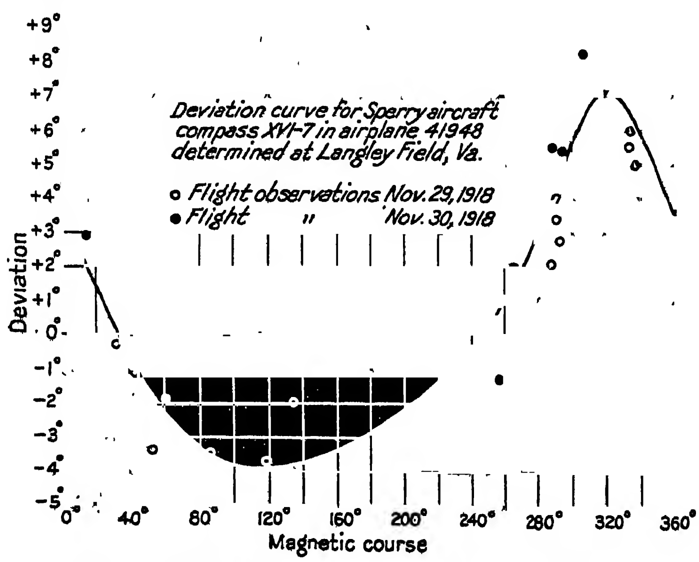


FIG. 11.—Compass Deviation-Curve for Airplane in Flight.

(*c*) The general impression obtained from the experiments was that the heavier gimbal-system with heavier counterbalancing gave better results.

(*d*) It would improve and facilitate readings of the shadow-pin device if the inside vertical edge of the circle were also graduated as well as the top surface; the graduated surfaces should be a dull white with black graduations and markings.

(e) Provided suitable arrangements were made to prevent gimbal-rings getting out of bearings, it is thought that the usual V-edge type of gimbal bearing would be as satisfactory as the ball-bearing and eliminate the magnetic materials necessary in the ball bearings.

(f) While effects arising from vibration were not as serious as expected (except in the case of the use of the artificial horizon as a horizon), the experiments indicated that a rubber support such as was used on November 29 and 30 would be of decided advantage, particularly if combined with a system of spiral springs to suspend the ring carrying the rubber pad.

(g) The results indicate that good values of declination can be determined on an airplane in flight, and that the compass may be used for navigation, proper precautions being taken in its mounting and treatment. A higher precision could, without question, be obtained by giving more attention to the design and improvement of the instruments used. A material improvement would doubtless be obtained by combining the compass, shadow-pin device, and artificial horizon in one instrument, as already suggested by Mr. Ault; this would make possible strictly simultaneous readings.

SUMMARY AND CONCLUSIONS.

The following is a brief summary of the work accomplished at Langley Field during the time covered in the foregoing reports:

The first problem was to test the usability of various artificial horizons for measuring altitudes from a moving airplane and to study different methods of rapid calculation and plotting of the position-line. The first apparatus used was a preliminary instrument consisting of a mirror mounted on small gimbal-rings with a counterweight suspended in oil to damp the vibrations. The results obtained with this instrument, using different types of sextants, gave an average error for a single observation of $\pm 25'$, and the error of a group of 10 was $\pm 12'$. During the second flight 59 observations were made, giving an average error of $\pm 12'$, rejecting only 3 observations which were obviously in error; all the others were less than 36′ in error.

A more accurate instrument (see Pl. 14, Figs. 1, 2, and 3) was manufactured by the Department and used in the experimental work at Langley Field. The mirror was made of speculum metal, and the gimbals were mounted on steel ball-bearings. The results obtained with this instrument gave an error for a single observation of $\pm 15'$ to $\pm 29'$ and an error for a group of six observations of $\pm 7'$ to $\pm 12'$.

Through the efforts of the Department a sextant with an artificial level-bubble attachment was secured from Professor R. W. Willson of Harvard University. With this instrument Doctor H. N. Russell obtained results which gave an error for a single observation of $\pm 12'$ to $\pm 21'$ and the error for a group of five of $\pm 6'$. The experience with this sextant showed material improvement over the mirror-and-gimbal horizon, both in ease and convenience of handling as well as in rapidity and accuracy.

After the altitude is measured, the next process is to make the calculations and to draw the position-lines on the chart or in some method determine the position of the observations. Several methods were investigated. First, the tables devised by Radler de Aquino, a Brazilian naval officer, were used, the computation with these tables requiring about 3 minutes and the plotting of the position-line about 2 minutes. These tables are published by the United States Hydrographic Office in Publication 200. Second, different methods of precalculation were studied. The best of these precalculation methods seems to be that outlined by Mr. G. W. Littlehales,[a] where some central position on a chart is taken as the assumed position of the observer and tables are precalculated on this basis. If Lambert's conformal conic-projection map is used, the arcs of great circles appear as straight lines and the altitude-intercept may be very large

[a] *U. S. Naval Inst. Proc.*, March 1918, pp. 567–584.

without appreciable error, so that one assumed position can be made to cover a wide extent of territory. Third, an instrument called the "line-of-position computer," designed and loaned to the Department by Professor Charles Lane Poor of Columbia University, was used. This instrument is probably the best that has been devised up to date for calculating the position-line in the air. It is made on the principle of a circular slide-rule, and both the altitude and the azimuth can be calculated in less than 1.5 minutes of time and to an accuracy of 2 minutes of arc.

Most of the experimental work in computing and plotting positions in the air was done by using Aquino's methods. With his tables, if both the altitude and the azimuth are observed, a previous knowledge of the dead-reckoned position is not necessary, except to determine the magnetic declination of the place of observation. With the natural horizon an observation was made, computed, and the position-line plotted in 4.1 minutes of time, and the mean error of four positions thus determined was ±1′. This shows something of the accuracy which can be obtained in making sextant observations where the uncertainty of the horizon is eliminated.

Some experimental work was done also on cloud and haze horizons at various altitudes, but the difficulty with such observations is to determine the altitude of the horizontal plane. A dip measurer was used to determine this altitude very successfully, the results giving an error of ±3′ to ±5′ for a single determination.

During a flight from Langley Field, Virginia, to Washington and return observations were made with the preliminary artificial horizon, using a small pocket-sextant. On the trip to Washington, which occupied 2 hours, 7 position-lines were determined, each based on 10 observations, and all work of computation and plotting of this line was done in the air without previous preparation, using Aquino's tables. The average time for each position-line, including observations, computations, and plotting, was 9.5 minutes. The average error of each line was ±13′ of altitude. On the return trip, which occupied 1¾ hours, 9 position-lines were determined and plotted with an average error of ±17′ of altitude. This increased error was due to the irregularity of motion due to "bumps," the ship falling 50 feet in a single "bump" quite frequently during the observations. The results in a set of 10 observations ranged over 3 degrees at times.

If such results can be obtained with preliminary apparatus and on small airplanes, it is quite certain that the errors can be materially decreased with more refined instruments and larger airplanes.

As previously mentioned, if only one celestial object is available, such as the Sun, then to completely determine the position the azimuth as well as the altitude must be measured. The experimental work along this line was interrupted before completion, but preliminary results were very encouraging. During the flight, when azimuths were first measured, 80 observations were taken and the error of groups of 10 was ±0°.6, the mean error of all being ±0°.3. The mean difference between deviations as determined on the ground and those determined in the air was only 0°.1. These observations were made with an azimuth-card the least graduation of which was 5°, the single degrees being estimated. Some further observations were made by J. A. Fleming, of the Department, and during his first flight he made 110 observations with the above-described instrument. The average time for 10 observations was 1.5 minutes, and the probable error of a single determination was ±0°.4.

As to instruments, a light sextant is desirable, but no difficulty was experienced in using the ordinary form of sextant. A special protractor was designed to facilitate the rapid plotting of the line of position. A chart holder and navigator's case was also designed and constructed by the Department.

Several flights were made at night to determine the practicability of observations on the stars. The results showed that observations could be made at night with the

same ease and accuracy as during the day. The advantage of night observations is the possibility of always having two objects on which to observe.

As to results as far as the experimental work was carried out, if two celestial bodies are available for observation a position should be determined within 20 minutes of time and to an accuracy of ± 15 miles at the outside. Where only a single celestial body is available and where both altitude and azimuth are determined, the resulting position may be in error from 30 to 60 miles. These figures should be reduced very materially with refined instruments and larger airplanes.

Upon his return to Washington the writer was asked by Army officers as to what he thought would be the successful method for navigating aircraft in the future. Without hesitation the reply was, by the use of radio. Navigation of aircraft by astronomical methods, which these reports show is practicable and feasible, is too slow and uncertain to be relied upon for future aerial development. During the daytime only one celestial body, the Sun, is available usually, and during a part of the day the trigonometric conditions are unfavorable. The resulting position, if no land objects are visible, will be uncertain, as indicated in the preceding reports. At night, navigation will be much more certain, as several stars or planets favorably situated for observing will usually be available, but clouds or fog may be present, which will prevent observations. This applies to daytime observations also.

The rapidity with which aircraft travel makes it necessary to keep a fairly accurate knowledge of the geographical position at all times. Future air-travel will demand a more rapid and accurate method for knowing this position than can be provided by astronomical means. This method undoubtedly will be furnished in the very near future by improvements in radio knowledge and in the adaptation of instruments for the navigation of aircraft by the use of radio.

THE COMPASS-VARIOMETER

By Louis A. Bauer, W. J. Peters, and J. A. Fleming

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THE COMPASS-VARIOMETER.

By Louis A. Bauer, W. J. Peters, and J. A. Fleming.

GENERAL DESCRIPTION AND FORMULÆ.

Compass-variometers have been designed by the Department of Terrestrial Magnetism suitable for the investigation of local magnetic disturbances, the detection of effects caused by hidden magnetic objects or materials, and for registering intensity variations with high precision. These instruments are a development from the so-called deviation compass of 1853 by Captain W. Walker and of 1862 by E. Dubois, the intensity compass of 1859 by F. I. Stamkart and of 1898 by A. Heydweiler, the double compass of 1901 by F. Bidlingmaier, and the sea deflector of 1905 by the Department. The principle of the compass-variometer may be described briefly as follows: Two magnets of equal magnetic moment suspended independently one above the other are so mounted that the distance between them may be varied to maintain a fixed horizontal deflection-angle for a particular, but not necessarily known, intensity of field. The sensitivity of such an instrument, that is, the change in the magnetic field causing a divergence of 1° from the fixed angle between the magnetic axes of the magnets, depends upon the magnitude of the fixed angle. The value of this angle must be adopted according to the requirements of the particular problem in hand. The magnets finally adopted were of the disk type made of very thin magnet steel magnetized in coils along fixed diameters and artificially aged. The constancy of the moments of such disks has been shown by the observations to be very satisfactory.

Between January 1918 and July 1919, four types of the compass-variometer were developed and constructed in the instrument shop of the Department (see Pl. 15). In the first model the magnets were damped electro-magnetically by copper dampers, while in the second and fourth models liquid damping was used; in these three models the magnets were mounted on pivots with agate jewels, the centers of gravity as usual being some distance below the point of support. In model 3 (liquid damping) and in auxiliary mountings of model 4, double-pivoted suspensions were used. While models 1 and 2 were found excellent instruments for observations on land, experiments carried out on board ship and in the laboratory of the Department with them and model 3 indicated certain improvements desirable to adapt the compass-variometer for use at sea; these were incorporated in model 4. They may be summarized as follows: (*a*) The use of a long-period inertia-gimbal system to increase the period of rocking to several times the period of the ship; (*b*) simplification of the means of observing so that an unskilled observer could use the instrument with high precision; and (*c*) reduction in weight of the variometer and more suitable provision to take care of expansion and contraction of the damping fluid.

The main features of the instruments as developed and constructed are summarized as follows: (*a*) Maintaining a fixed relation between the axes of the magnets or magnet-systems making possible, in connection with (*b*), the construction of a short-period detecting instrument suitable for rapid surveys of high precision and investigations of magnetically disturbed regions, for example, magnetic fields in buildings, magnetic fields about iron ships, regions of local disturbance in the Earth's magnetic field; (*b*) the arrangement for readily changing the distance between the magnet-systems to obtain the position of equilibrium of the magnets on any course, thus *adjusting mechanically* for variations in the magnetic field caused by the ship's magnetism; (*c*) the disk

type of magnet and the axle-mounting for use at sea which make possible accurate balancing of magnets or magnet-systems, thereby decreasing troublesome dynamic effects on board ship; (*d*) the arrangements of single containers making automatic provision for all expansion and contraction of the damping liquid without setting up disturbing currents; (*e*) the optical arrangements for eliminating parallax, thus reducing uncertainties and inaccuracies of observation both on shipboard and on land; and (*f*) the design of the inertia-gimbal system, combining long periods with ease of manipulation and observation.

An exhaustive exposition of the theory of double compasses in general, which also applies with obvious limitations or exceptions to the compass-variometer, is given in Bidlingmaier's Doppelkompass.[a] If H is the horizontal component of the field under investigation, ϕ and ϕ' are the horizontal angles that each magnet is deflected from the meridian, m and m' are the magnetic moments of the two magnets, ψ is the angle between two imaginary vertical planes passing through their magnetic axes, e is the vertical distance between the two magnets, and D is a factor dependent upon the distribution of magnetism in the two magnets, then the fundamental equation is

$$H \cos \frac{1}{2}(\phi - \phi') = D \frac{m+m'}{e^3} \cos \frac{1}{2}\psi \quad (1)$$

For the C. I. W. variometers as constructed, m was made equal to m', in which case equation (1) becomes

$$H = \frac{2m\,D}{e^3} \cos \frac{1}{2}\psi \quad (2)$$

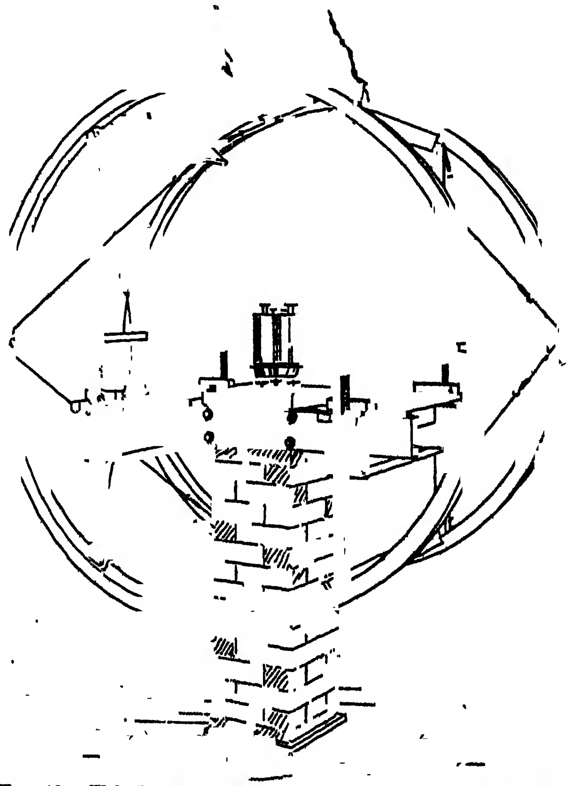


FIG. 12.—Helmholtz-Gaugain Testing-Coils for calibrating Compass-Variometers.

The factor D can be determined from equations (1) or (2) when all other terms are known. Thus

$$D = \frac{e^3 H}{2m \cos \frac{1}{2}\psi} \quad (3)$$

Values of D for compass-variometer 1 on March 1, 1918, are given by way of illustration, as derived from the following data:

ψ	60°	90°
e, in cm	6.50	6.06
H, in C. G. S. unit	0.135	0.135
m	22.9	22.9
for which we have D	0.935	0.928

Compass-variometers 1 and 2 were calibrated by using them to detect changes in the uniform field of a Helmholtz-Gaugain coil arrangement,[b] Figure 12.

[a] BIDLINGMAIER, F. Der Doppelkompass, seine Theorie und Praxis. Deutsche Südpolar-Expedition, 1901–1903, Bd. V, Erdmagnetismus I.

[b] WATSON, W. Textbook of Practical Physics, 1913, p. 509; P. H. Dike, Experimental Investigation of Dip Needle Corrections, *Terr. Mag.*, vol. 14, 1909, pp. 137–146.

A typical set of calibration determinations made at Washington on March 28 and 29, 1918, for compass-variometer 1 is given in Figure 13, which gives the values of H as ordinates for the micrometer readings of the distances e as abscissæ.

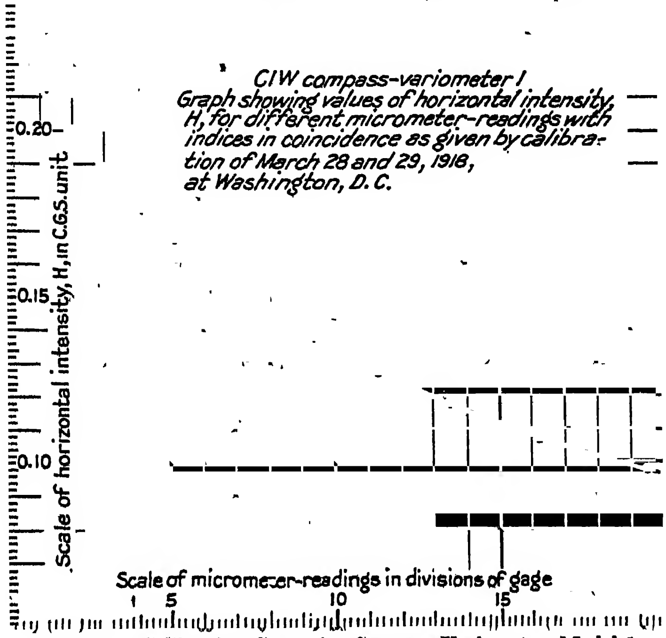


FIG. 13.—Calibration Curve for Compass-Variometer, Model 1.

All C. I. W. compass-variometers may be used according to one of two methods for measuring small variations in H. The distance e can be kept fixed, in which case the changes in H are deduced or simply noted from the changes in the angle ψ, or the angle ψ may be kept constant, in which case the changes in H are deduced from the changes in the distance e.

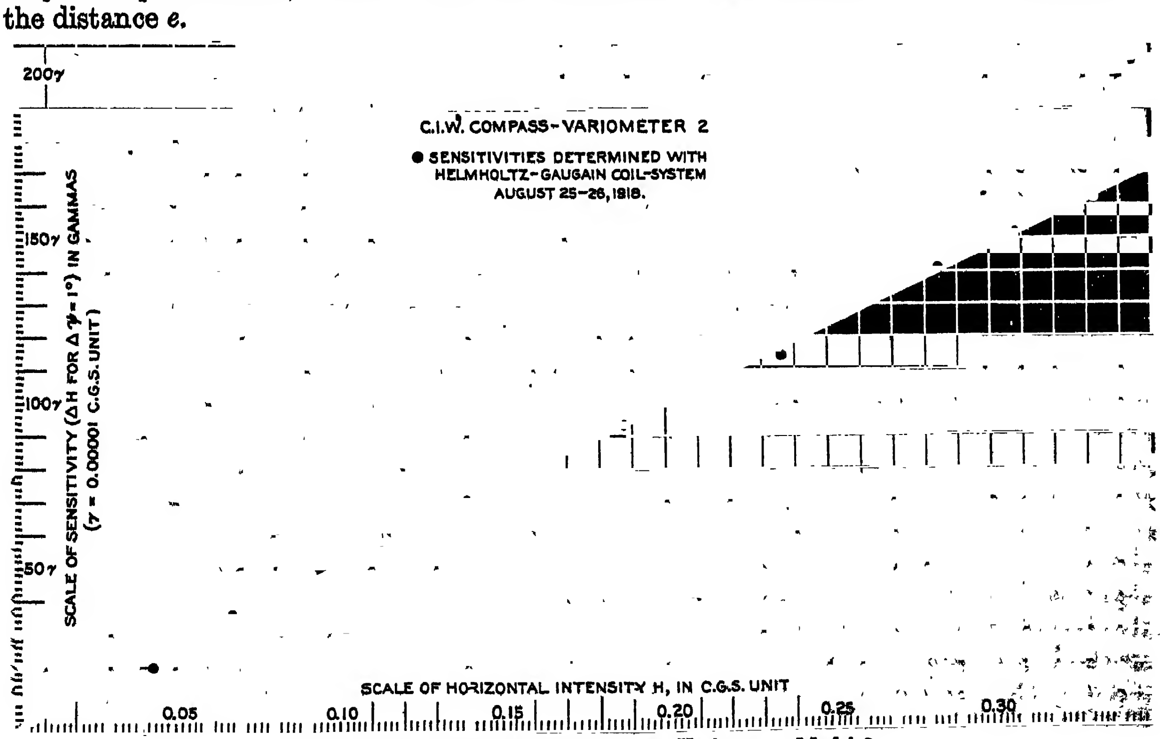


FIG. 14.—Sensitivity Graph for Compass-Variometer, Model 2.

To calculate the sensitivity or the value of ΔH for $\Delta\psi = 1°$, for a proposed fixed distance, this distance e is regarded as constant and equation (2) gives

$$\Delta H = -\frac{D\,m}{57.3\,e^3} \sin\frac{\psi}{2}\,\Delta\psi \tag{4}$$

For a proposed fixed angle and variable distance e the same equation gives

$$\Delta H = -\frac{6m\,D}{e^4} \cos\frac{1}{2}\,\psi\Delta e \tag{5}$$

The sensitivity may also be determined by observations made during calibration of the instruments. Results of observations for sensitivity in compass-variometer 2 made on August 25 and 26, 1918, at Washington are plotted in Figure 14, in which the sensitivity as for $\Delta\psi = 1°$ is given by the ordinates for values of H as abscissæ.

Used as a detector for locating a mass of hidden iron or magnetic material, the instrument is simply adjusted to the proper sensitivity by a judicious selection of the angle ψ; but when used to make a rapid survey or to determine any small changes in the field, as in the investigation of magnetic effects during solar eclipses, it is necessary to calibrate the instrument, which can be done most satisfactorily in the Helmholtz-Gaugain-coil arrangement.

DETAILED DESCRIPTIONS.

C. I. W. compass-variometer 1.—This design is based upon electro-magnetic damping and utilizes single-pivot magnet-systems. The disk-magnets, 22.5 mm. in diameter and 0.3 mm. thick, are copper-plated to protect them against deterioration. The instrument, constructed in 1918, is shown in detail in Figure 15 and by Figures 1, 3, and 6 of Plate 15. The distance between the two magnets may be regulated by the micrometer-screw, which operates the double knee-lever to which the copper damping-boxes containing the magnets and pivot-mountings are suitably attached on rods free to move vertically in long bearings. Fine quartz-rod pointers, or indices, are attached to the cone-shaped aluminum jewel and magnet support, the pointer of the upper magnet being in the vertical plane through its magnetic axis, that of the lower magnet in a vertical plane at the angle ψ from its magnetic axis (in general the angle ψ was made 60°). Quartz rods are used for the pointers, as they are extremely stiff, even when of very small diameter, and add very little to the moment of inertia of the moving system.

Viewing the instrument through a 3-inch reading lens, one sees the quartz pointer of the lower system and the reflection of the pointer of the upper system from a mirror centrally placed as regards the magnet-systems; thus parallax is eliminated and setting for coincidence of the two pointers may be made quite readily by altering the distance between the magnets by turning the micrometer-screw. It is to be noted that a graduated circle (photographed on glass) is mounted approximately in the plane of the reflecting mirror to permit: (*a*) observing angles between the two pointers and hence changes in horizontal intensity (H, as indicated by equation (4), in case it is desired to clamp the micrometer-screw at one setting corresponding to a fixed value of H); and (*b*) observing changes in magnetic declination through orientation on a fixed mark by means of a quartz index mounted on the movable index-ring (see Fig. 15). The arrangement (*a*) is suited for observations of the magnetic diurnal-variation, as at an observatory, although the method of reading micrometer-settings for coincidence of pointers is also readily used, as indicated by equation (5). The orientation of the instrument may also be controlled in connection with a suitable sighting device by the graduated circle on the base, which carries the instrument in a coned bearing provided with clamping screw. The instrument is leveled for observations on land by the foot-screws and level

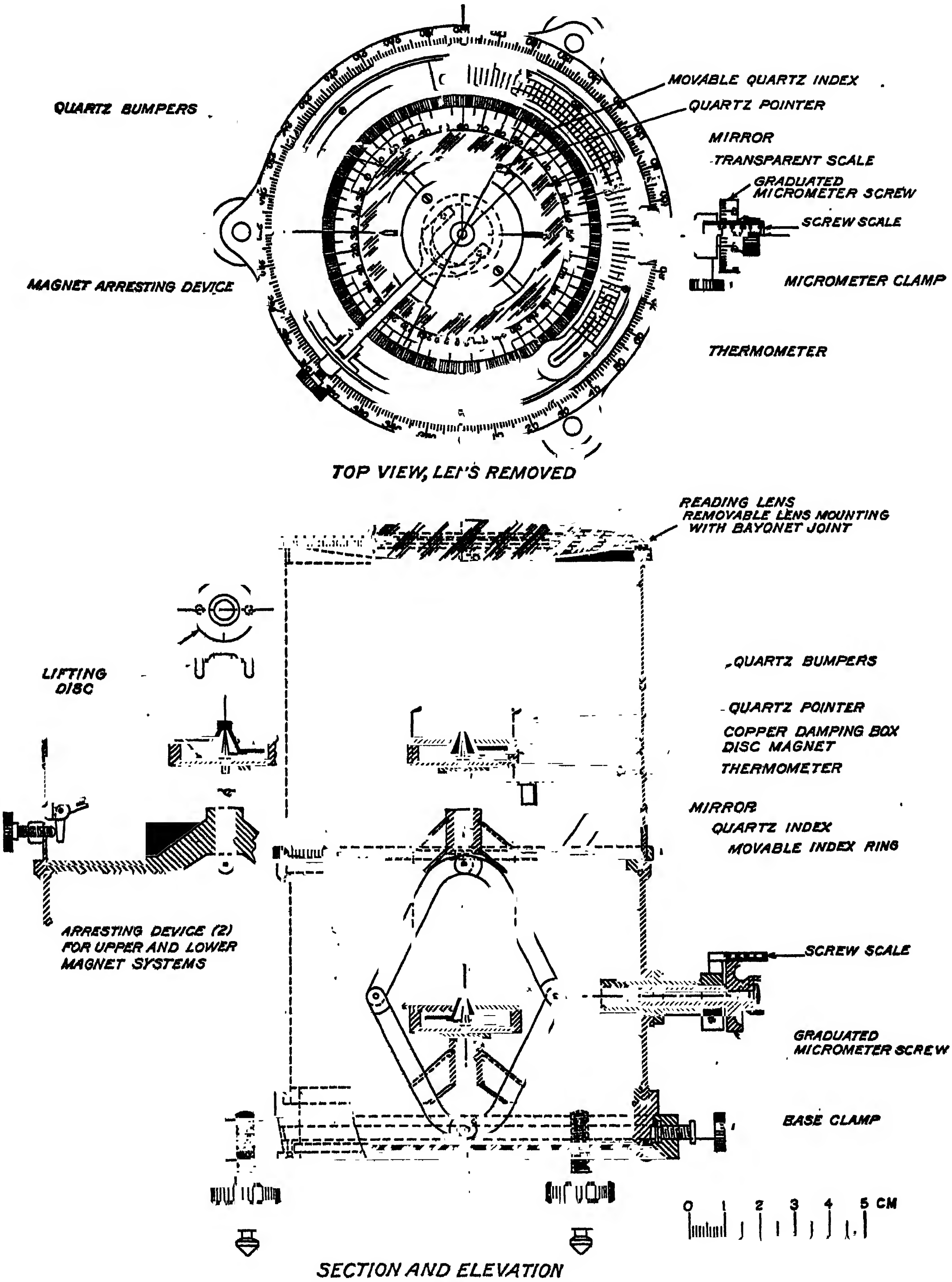


FIG. 15.—Compass-Variometer, Model 1.

attachment on the base. A curved thermometer mounted inside the case makes provision for the necessary temperature readings.

To prevent damage to the pivots and jewels during transportation, arresting devices are provided for each magnet-system by which the magnets may be raised and clamped against the tops of the damping-boxes (these tops are screwed in place); the clamps are operated by screws from the outside of the instrument case (see Fig. 15).

As there are two positions of equilibrium, that is to say, for the fixed deflection-angle ψ and $(180°-\psi)$, two "bumpers" of thin quartz-rod are provided, as indicated in Figure 15, these serving to restrain by contact with the quartz pointers of the magnet-systems the freedom of motion of the magnets, so that the second position of equilibrium may be avoided.

For illumination of the pointers, graduated scale, and mirror, the interior of the instrument-case is silvered in a velvet finish and a ground-glass bottom is provided. These are quite satisfactory for work during the day, while for night work suitable reflectors for throwing light through the bottom are found sufficient.

The constancy of magnetic moments may be illustrated by Table 43, giving values of moments determined for four typical disk-magnets 1, 2, 3, and 4, taken at random.

TABLE 43.—*Magnetic Moment of Typical Disk-Magnets for C. I. W. Compass-Variometers.*

Date	Temp.	Observed magnetic moment of magnet 1	2	3	4
1918	°*C*	*c.g.s.*	*c.g.s.*	*c.g.s.*	*c.g.s.*
May 7	25	21.0	24.4	24.1	23.6
Aug 9	31	20.9	24.5	24.0	23.5

The magnets for an instrument were selected so as to have practically equal moments; for the magnet-steel used, the moments of magnets of the dimensions adopted average from 23 to 24 C. G. S. units.

C. I. W. compass-variometer 2.—In C. I. W. compass-variometer 1 the electromagnetic form of damping the magnets proved successful when the instrument was used ashore, but was found unsuitable for observations at sea. Accordingly, in the second model C. I. W. compass-variometer 2, a liquid form of damping was introduced and some further constructional improvements were made in 1918, the general principle remaining, however, the same as for model 1. Model 2 consists of two independently pivoted magnetized disks (diameter 22.5 mm., thickness 0.3 mm., magnetic moments about 24 C. G. S. units at 20° C.), one mounted vertically above the other, at a distance which may be varied with a micrometer-screw from about 40 mm. to 90 mm., corresponding to magnetic fields varying in horizontal intensity from 0.35 to 0.05 C. G. S.

In order to provide for a rapid means of adjustment, a fixed horizontal angle of about 60° between the axes of the two magnetized disks was adopted, the distance between the magnets being varied with the micrometer-screw as necessary to obtain this adopted angle immediately preceding an observation. The sensitivity of the variometer would then be approximately 1° = 0.00021 C. G. S. for a field of 0.05 C. G. S., and 1° = 0.00171 for a field of 0.35 C. G. S. This range in the distance appeared to be generally sufficient for a suitable mounting even on a steel vessel, though, if found necessary, a greater range can readily be introduced.

When the variometer is brought into the influence of a disturbed magnetic field, the effect is either to decrease or increase the adopted angle of 60°. To expedite the detection of this superposed effect, the pointer attached to the lower magnetized disk is set off at an angle of 60° from its magnetic axis. Hence, in order to set the instru-

ment to detect a local disturbance, it is only necessary to turn the head of the micrometer-screw until the pointer of the lower magnet is vertically below the pointer of the upper magnet, when by means of a special reflecting system, the pointers will appear in coincidence; this is the zero setting, which may be read on the micrometer-head. When the zero setting has been made for the Earth's magnetic field, undisturbed or combined, as, for example, with that of a ship, any change in this field is disclosed by an opening ("scissoring") of the two pointers, the angular amount being read on a graduated arc by looking down through the magnifying glass forming the top of the instrument. (See Plate 15, Figs. 7, 8, and p. 344.) According to the direction in which the pointers move relatively to each other, it is possible to determine whether the change was due to a diminished or increased intensity of the magnetic field for which the zero setting had been made. The pointers consist of quartz fibers rigidly fastened to the magnetized disks, the north end of the upper pointer being colored red and that of the lower pointer black; the south ends are colored, respectively, green and black. The mechanical details of the magnet systems and the method of changing distance between them are shown by Figure 7 of Plate 15.

With the liquid damping, the period of the combined magnet-system is about 2 seconds for a field of 0.18 c. g. s. C. I. W. compass-variometer 2, as designed, detects primarily changes in horizontal intensity, but it may also detect changes in compass direction (magnetic declination) on land or at sea if for the short time requisite a fixed line of reference is provided by some means, as, for example, by some gyroscopic control, or if the ship can hold her course sufficiently steady, i. e., within an angular amount less than the effect under investigation. The horizontal-intensity effect is measured by the double deflection-angle, making the instrument practically independent, during the short period of its use, of small changes in the ship's heading. The instrument is suspended in gimbal-rings and mounted on a brass stand as shown in Figure 5 of Plate 15. An inner gimbal-system was also introduced in the experimental model, but sea tests seemed to indicate that this inner system may be dispensed with.

The general dimensions of the model 2 are as follows: outer diameter 18 cm., height 26 to 30 cm., weight with the liquid damping system 10 kg. It is possible to reduce these dimensions, and the weight to 10 pounds or less. A magnetized disk was used as in model 1 for the form of the magnets in order to reduce the oscillation and minimize dynamic deviations.

C. I. W. compass-variometer 3.—As indicated by Figure 4 of Plate 15, model 3 was a somewhat crude experimental apparatus of as simple design as possible, constructed for the purpose of testing the feasibility of the double-pivoted suspension. The disk-magnets are of the same dimensions as for the other models. The jewels and shaft support are quite similar mechanically to those for model 4, the lower agate bearing being of the usual compass type, with cone-shaped cup coming practically to a point and the upper bearing being of the chronometer hole-jewel type (diameter of hole 0.14 mm.) with watch-cap jewel suitably mounted to allow vertical play of the shaft of not more than 0.05 to 0.08 mm. The shafts were constructed of aluminum, with steel pivots crimped in place.

Inertia-gimbal system for compass-variometer 4.—One of the essentials of a variometer for use in detecting local disturbances at sea is that the periods of the magnets must be short, preferably not over 2 seconds, in order that results may be obtained without reducing the speed of the ship. The gimbal device for mounting the instrument on shipboard must have a long period and yet one quite different from that of the ship, as otherwise the amplitude of the gimbal oscillations would increase to a prohibitive degree. Now, the oscillations of a *perfectly-balanced* disk-magnet, axle-suspended, are caused only by the tilting of the plane of the disk, and if the tilting is slow enough, that is to say, if the period of the gimbal is long, the regular oscillations of the magnet can be

differentiated from an effect lasting only 1 or 2 seconds caused by sailing over a small area of local disturbance.

Such a mounting can be obtained by having the gimbal-system made up of hollow spheres or rings, the centers of gravity of the units of the system being slightly below the axes of support. Difficulties of mechanical construction prohibit practically the use of hollow spheres, and the form, therefore, adopted consisted of thin rings of large diameter mounted with their planes perpendicular to their horizontal axes of rotation in order to secure maximum radius of gyration. A gimbal unit mounted so as to have the longest period would consist of two rings rigidly connected, mutually perpendicular, mounted vertically, and movable about a horizontal axis lying in the central vertical plane of the one, the supporting ring, and perpendicular to the plane of the other, the inertia ring. Such units can be readily made symmetrical and can be readily balanced. For any system of rings the period can be increased by decreasing the displacement of the center of gravity below the intersection of the axes supporting the two sets of rings. Theoretical considerations show also that the masses of the rings should be as great as is possible, not because of period but to increase the couple resisting the friction at the points of support. The angular acceleration of the system will be proportional to the frictional torque and inversely proportional to the moment of inertia; the ball-bearing supports being greased, the laws of fluid friction hold and the angular acceleration is, therefore, also inversely proportional to the mass, and hence the masses of the units should be as great as possible according to experiments by Tower and to theory by Reynolds on ball bearings.[a]

In this connection it is interesting to note that the principles involved here were used as early as 1873 by William Froude in the construction of an instrument for automatically recording the rolling of ships.[b] About 1878 E. Bertin also made experiments with a "double oscillograph;" his results were published in Cherbourg in 1878 under the title, "Observations de roulis et de tangage faites avec l'oscillographe double."[c]

Various experiments were made by the Department of Terrestrial Magnetism with a heavy inertia-wheel mounted on wooden swings which had periods of about 2 seconds, and finally in 1919 the inertia-gimbal system as shown by Figure 2 of Plate 15, and Figure 16 (the detail sketches of the cells are drawn to twice the scale of section and elevation) was designed for the new model variometer to be used on a vessel of relatively short period. The weights and dimensions of the inertia-gimbal system are as follows: The rings of the inner system weigh 49.9 kg. (110 pounds) and are 40 mm. thick, 80 mm. wide, and 503 mm. outside diameter. The rings of the outer system weigh 73.9 kg. (163 pounds) and are 20 mm. thick, 80 mm. wide, and 555 mm. outside diameter. The yoke carrying the two sets of inertia rings weighs 49.9 kg. (110 pounds) and its greatest dimensions are 35 cm., 35 cm., and 65 cm. The spindle attached to the yoke weighs 31.8 kg. (70 pounds) while its bearing base in the wooden frame weighs 31.8 kg. (70 pounds). The total weight of the rotating portion of the gimbal-system is 205.4 kg. (453 pounds). The period of oscillation from one extreme to the other is 21 seconds, the displacement of the center of gravity below the point of intersection of the two bearing axes being about 0.3 mm. The over-all height of the instrument from the top of wooden supporting base is about 70 cm. The ring systems are supported by small steel ball-bearings, 13 mm. in diameter; these bearings have but little magnetic effect upon the variometer placed at the center of the system.[d]

[a] *Cf.* Encyclopaedia Britannica, 11th edition, v. 3 (581–582).

[b] FROUDE, WILLIAM. Description of instruments for automatically recording the rolling of ships. *Trans. Inst. Naval Architects*, v.14, (179–190) 1873.

[c] WHITE, W. H. Naval Architecture.

[d] The S K F Ball Bearing Co. of Hartford, Conn., made up for the Department some special test-bearings in Rudin bronze, which, however, were not received in time to be incorporated in the inertia-gimbal system as made. Rudin bronze is practically nonmagnetic. Its composition is as follows: Copper, 80 per cent; iron, 5 per cent; aluminum, 12 per cent; nickel, 3 per cent. One of these special bearings on test produced no magnetic effect upon a delicate testing-apparatus at a distance of 6 cm. Such bearings would, therefore, produce no magnetic disturbance on the variometer if used for a gimbal-system of the dimensions indicated above.

The gimbal device may be oriented so that the line of sight will not be obstructed by any of the rings on any heading of the vessel. The orientation may be read on a horizontal circle graduated to single degrees; such settings, having an accuracy of one-

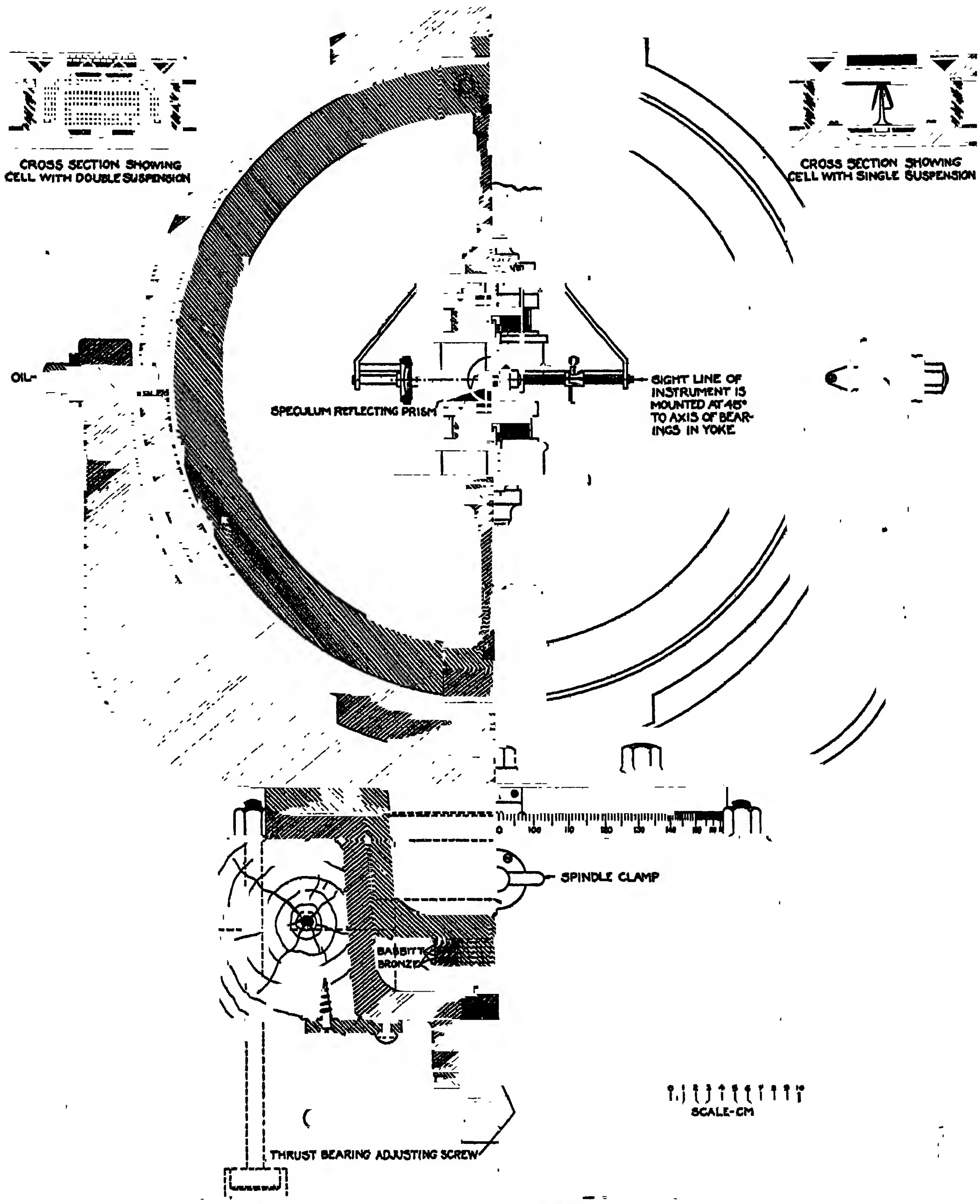


FIG. 16.—Compass-Variometer, Model 4, and Inertia-Gimbal System for Mounting on Ship.

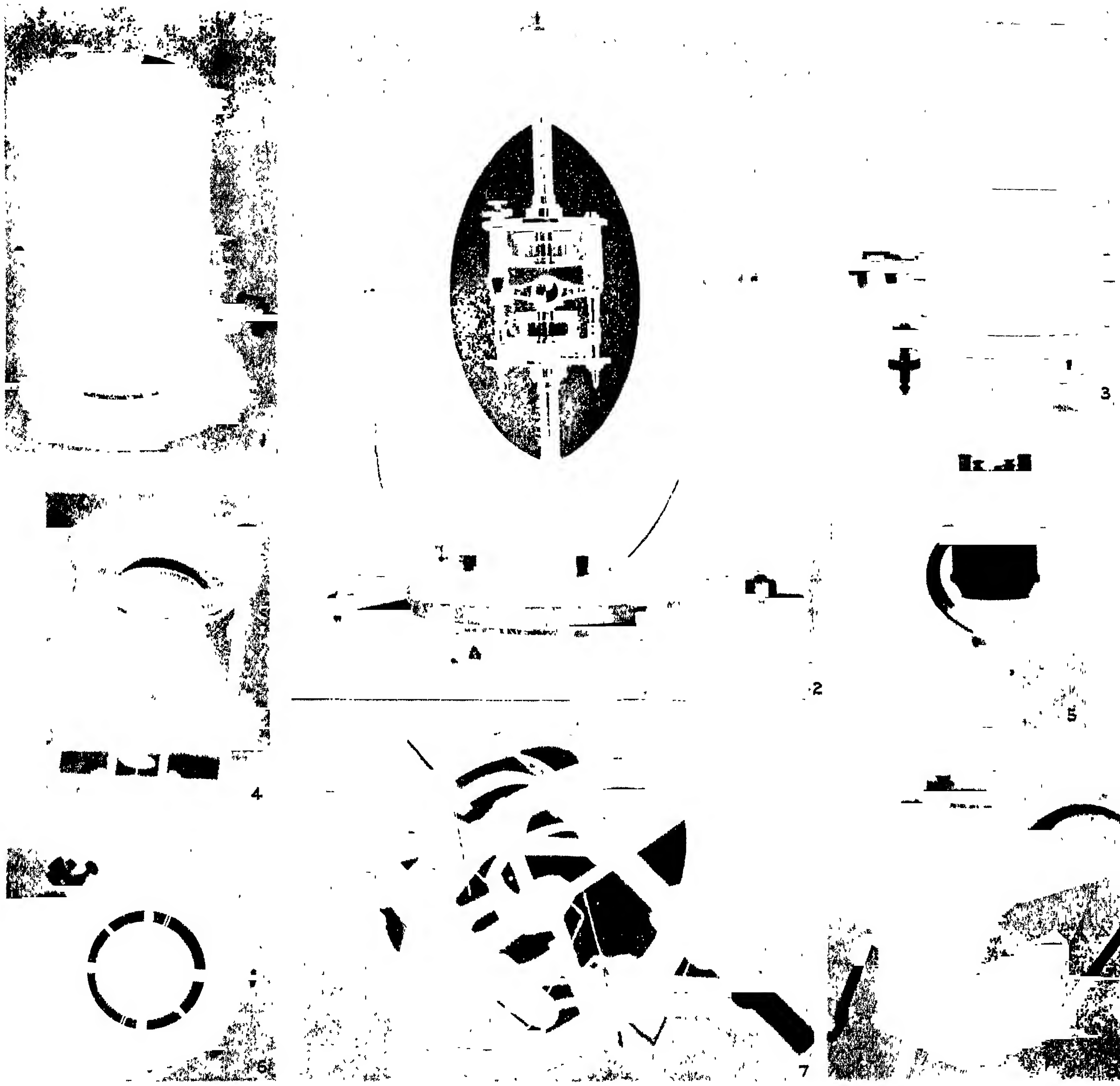
quarter degree or even better, can be easily made. The half section of the instrument shown in Figure 16 gives the detail of the spindle-bearing and of its adjustment.

C. I. W. compass-variometer, model 4.—The general principles involved in model 4 of the C. I. W. compass-variometer are the same as those for the second model, constructional modifications and improvements being introduced in 1919 to adapt the instrument more particularly for use at sea.

This type of variometer consists of two independently pivoted magnetized disks (diameter 24 mm., thickness 0.3 mm., magnetic moment about 26 C. G. S. units), each mounted in an individual cell with liquid damping, so constructed that the cells may be placed on carriages one vertically above the other. The frame for the carriages is so arranged that the distance between the two cells may be varied between 43 mm. and 105 mm. with a screw. This range in distance permits using the instrument in magnetic fields of any horizontal intensity between 0.4 C. G. S. and 0.04 C. G. S. The screw is provided with a micrometer-head, so that the vertical distance between the two magnets may be read directly in millimeters to the nearest 0.01 mm., and by estimation even more closely. The micrometer-head and index have been added to the instrument illustrated by figures of Plate 15 and Figure 16 only to investigate calibration and sensitivity of the instrument, the micrometer reading-device not being necessary when the instrument is used as a detector. The screw-thread has a pitch of 0.5 mm., the upper portion being right-handed and the lower portion left-handed; thus a complete turn of the screw produces a change of 1 mm., in the vertical distance between the magnets.

Changes in the ship's deviations are provided for by turning the screw until the vertical planes through the magnetic axes of the two disk-magnets include an angle previously selected. The choice for the magnitude of this angle is governed by consideration of sensitivity. The angle provisionally adopted was 60°, for which the sensitivity is approximately 1° = 0.0002 C. G. S. in a field of 0.05 C. G. S. and 1° = 0.0017 in a field of 0.35 C. G. S. The effect on entering a disturbed field is revealed by a change in the adopted angle. To facilitate observing the effect, the under surface of the upper disk and the upper surface of the lower disk are graduated at 10° intervals and a reference diameter on the lower magnet is marked at an angle of 60° from its magnetic axis by the letters *N* and *S;* the graduations on the magnetic-axis diameter are marked by a single cross at the north-seeking end and by a double cross at the south-seeking end, thus † and ‡ The "zero setting," that is, the setting for detection purposes on the given course and for which the included angle between the magnetic axes is 60°, is made by turning the head of the micrometer-screw until the similarly-lettered graduations appear as on the same straight line in the field of the magnifying lens (see Fig. 17). When this setting is made the instrument is adjusted for the resultant magnetic field of the Earth and of the vessel on the course traversed; any effect occasioned on passing through a disturbed field is disclosed by the displacement of the two lines with reference to each other, the angular movement being estimated directly from the graduated arcs as viewed through the magnifying lens. It should be noted that the adjustment referred to is entirely mechanical and requires no previous knowledge of the ship's deviations or of the Earth's field. Whether the disturbing effect is to diminish or to increase the intensity of the normal magnetic field can be determined from the direction in which the marked graduation of the lower magnet moves relatively to the axis graduation of the upper magnet.

The optical arrangement is shown schematically in Figure 17. The reflecting mirrors are the highly-polished surfaces of two right-angled speculum prisms. The horizontal distances of these prism surfaces from the central axis of the instrument may be adjusted by means of supporting rods and clamping screw, thus making it possible to alter at will the distance between the images of the scales as seen through the lenses. The



CARNEGIE INSTITUTION OF WASHINGTON COMPASS-VARIOMETERS.

1. Model 1 type.
4. Lens support and slow-motion system with double-pivoted magnets of model 3.
6. Model 1 as viewed in use showing quartz-fiber indices, mirror, and graduated circle.
2. Model 4 as mounted in inertia-gimbal support on ship.
7. Complete inner supporting-system of model 2 showing magnets, scales, bumpers, and speculum mirrors and reflectors.
3. Model 1, side removed, showing lower magnet damping-box, knee-lever slow-motion system, and magnet arrester.
5. Model 2 as mounted on ship.
8. Model 2 as mounted in carrying-case for observations at land station.

optical arrangement on one side is duplicated on the other in order to preserve symmetry of balance. The double arrangement also permits two persons to observe at the same time or gives one observer a choice in which he may be guided by conditions of illumination. The lenses for magnification of the angular motion are mounted on screws which are operated by means of miter gears attached to them and to the micrometer-screw from which the magnet-cell carriages are supported. The pitch of the screws carrying the lens mounting is 0.5 mm., that is, the same as that of the micrometer-screws. Since the speculum mirrors are fixed centrally between the magnets and the lens mountings are so arranged that the disk-images are in focus, the focus is maintained for any other setting, the lenses being moved in or out one-half the distance that the magnet-cells are moved apart or together. This eliminates the long filament pointers used for the previous models, which were objectionable at sea because they alter the symmetry of mass and because they make a larger container necessary, thus increasing the weight of the instrument and the volume of damping liquid. On the other hand, the resulting accuracy of setting is less than in the previous models, but for use as a detector on shipboard the magnification in the present instrument is sufficient; divergences of 2° may be easily noted. As indicated in Figure 17, fine quartz index-rods are mounted just below the magnetized disk, thus giving by reflection from the speculum mirrors a fixed reference line in the field of view. This reference line will also permit detection of any changes in compass direction caused by disturbing influences.

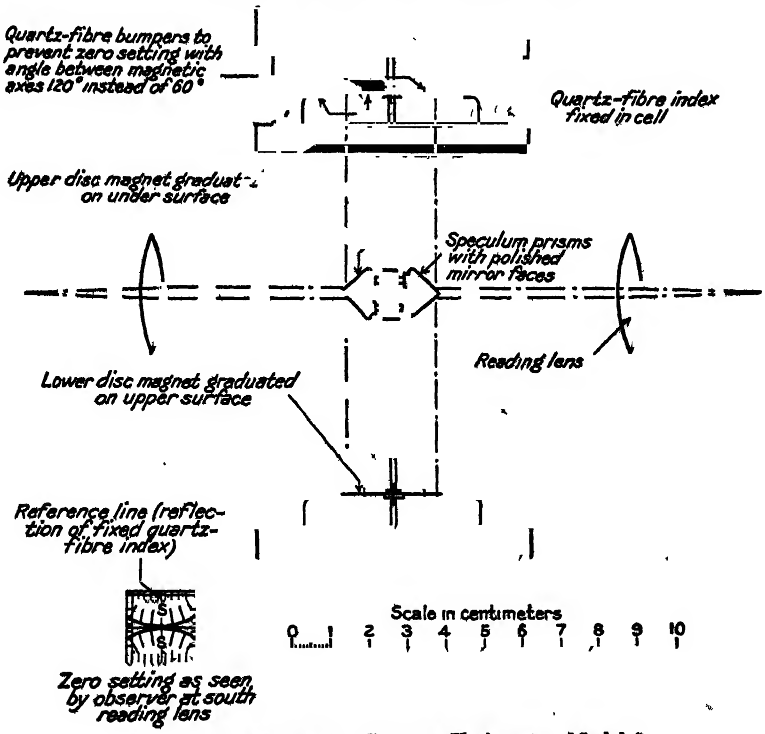


FIG. 17.—Optical System, Compass-Variometer, Model 4.

In addition to the equilibrium position of the two magnet-systems with the angle between their axes at 60°, there is also possible a second equilibrium position for the same vertical distance between the magnet-systems in which the angle between the two magnetic axes would be 120°. When the heading of the ship is changed or when there are great changes in horizontal intensity on different courses, the magnet-systems might sometimes take up this second position of equilibrium. To avoid this and to provide means for bringing the magnets into their proper relative positions for the displace-

ment angle of 60°, four short quartz-fiber bumpers are mounted symmetrically on perpendicular diameters in the disk-magnets. These fibers are just long enough to touch the quartz-fiber index-rods shown in Figure 17, and therefore restrict the departure of the magnet-systems from equilibrium to an angle of 45° on either side of the position of equilibrium. In case the magnet-systems are found to have taken up the second position of equilibrium, it is only necessary to turn the whole instrument in azimuth until the bumpers come in contact with the quartz rods and then change the distance until the proper displacement relation may be effected on again orienting the line of sight of the variometer.

The individual container or cell, for housing each magnet with its mountings and the damping liquid, is shown in detail by Figure 16. This design makes it possible to replace cells on the original mounting as desired. It also provides more satisfactory means for the expansion and contraction of the damping liquid. This is done by drilling in the top metal part of the cell, as indicated in Figure 16, a number of inverted cones, having very small holes at their tips opening into the main body of liquid in the cell. The combined volume of these cones is more than sufficient to allow for the expansion and contraction resulting from a change of 50° C., assuming the coefficient of expansion of the liquid per degree centigrade to be as great as 0.0015. The smallness of the openings into the cell precludes any surging that might cause currents in the liquid. It will be noted from Figure 16 that the inside of the cell is provided with a metal gauze or screen for protection against possible electrical disturbances occasioned by the action of the wind on the exposed glass surfaces.

The carriage for the mounting of the cells has a total height of 19 cm., while its greatest horizontal dimension is 25 cm. The variometer may be easily removed from its supporting standards in the inertia-gimbal system. It is provided with three legs, so that it may be set up and calibrated at shore stations or may be used for the detection and examination of local disturbances in horizontal intensity on land also. The weight of the variometer alone with its two cells is 4 kg. (9 pounds), as compared with about 10 kg. (22 pounds) for variometer 2. The weight of a single cell complete with gasoline is 0.5 kg. (1 pound).

Some experiments have been made to find a more suitable liquid for damping than gasoline as heretofore used. It is very desirable, particularly so in the case of an axle-mounted magnet, to reduce the pressure on the lower bearing, for example by the buoyant effect of a denser liquid. Some experiments have been made with acetylene tetrabromide (Muthmann's solution), which appears to be the heaviest liquid (specific gravity 3) that has all of the other desirable properties, namely, transparency, permanency, inertness, and mobility at ordinary temperatures. The results of experiments with this liquid are promising, but so far not conclusive. The period of each magnet in gasoline is about 2 seconds in a field of horizontal intensity 0.19 C. G. S. With the acetylene tetrabromide as the damping liquid the magnet systems are almost entirely dead-beat. The damping liquid also acts to some extent as a lubricant for the pivot bearings of the magnet.

As shown in Figure 16, two types of magnet-mountings have been made for experiments with variometer 4. One is the ordinary single-pivot suspension as used in models 1 and 2, and the other is of the axle-mounted type, the bottom pivot being carried in a jewel bearing and the upper in a hole-jewel bearing, such as is used for chronometer movements, with the smallest practicable amount of play. The chief difficulty with either of these types is in balancing. Despite the greatest care in construction, it is found impossible to make either axle-mounted or single-pivoted magnets which are perfectly balanced. Final perfection in balance is effected by the addition to the disk of small masses, for example of shellac, when gasoline is used as the damping liquid.

The location of the balancing material may be determined by observing the behavior of the disk-magnet when, mounted in its bearings, it is subjected to periodic rectilinear motions in various magnetic azimuths. Since true balance is effected by method of repeated trial and test, the operation is quite tedious and requires painstaking care.

APPLICATIONS.

The use of compass-variometer 2 is illustrated in the following description of a rapid survey made to determine the magnetic field around a steel ship.

Observations were made in dry-docks by observers H. W. Fisk and H. R. Grummann, of the Department of Terrestrial Magnetism of the Carnegie Institution of Washington, as follows: May 22, 1919, with ship A in dry-dock No. 1; May 30, 1919, at the same station as on May 22, 1919, in empty dry-dock No. 1.

The magnetic horizontal-intensity was measured by H. W. Fisk, using compass-variometer 2, and the magnetic declination and inclination were determined by H. R. Grummann, using dip circle 241. The compass-variometer was mounted in a non-magnetic carriage built for the purpose, and was always carefully centered at very nearly the same height above the station points with ship in dock as when dock was empty. Slight variations in height may have been produced by the use of the leveling screws, but these may be considered negligible. The micrometer-gage of the instrument was read and the value of the horizontal intensity corresponding to this reading was taken from the calibration curve determined at the standardizing Magnetic Observatory of the Department of Terrestrial Magnetism. The dip circle was mounted on a block so that the center of the instrument was at approximately the same height as that at which the compass-variometer was used, viz, about 11.75 inches. The method of determining declination and inclination was as follows: After being centered over the selected point, the instrument was turned so that the suspended needle stood vertical, indicating that the instrument was in the magnetic prime-vertical, and the azimuth circle read; the instrument was then turned in azimuth through 90° and the upper end of the needle was read, this reading giving the inclination with close approximation. A reading was then made on a mark, by sighting through the sighting vanes of the compass attachment[a] of the instrument, so selected as to determine a line parallel to either the longitudinal or the transverse axis of the dock (according to the conditions at the point of observation) and the azimuth circle again read; this reading, combined with that of the prime vertical, gave the magnetic declination with reference to the orientation of the axis of the dock.

The points in dock 1 were marked by cutting a cross in the concrete floor or step.

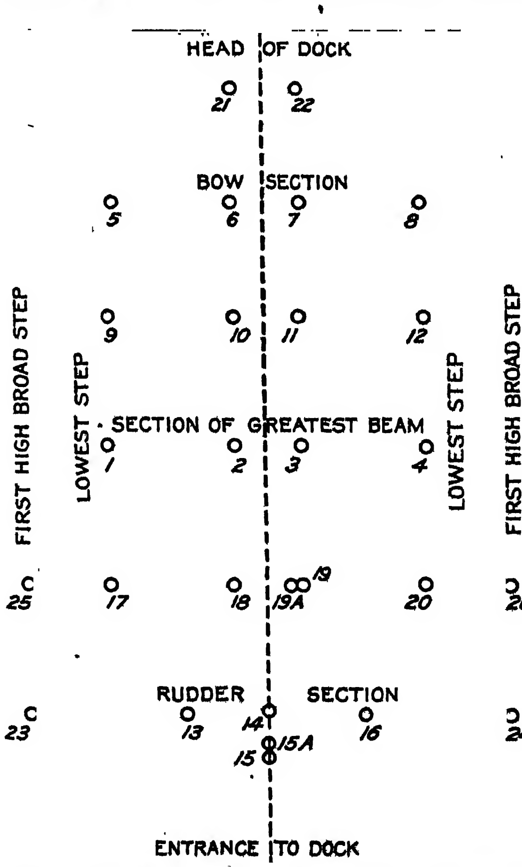


FIG. 18.—Location of Magnetic Stations for Magnetic-Disturbance Survey in Dry-Dock 1.

[a] The compass needle and its steel pivot were removed from compass attachment before observational work was begun.

Observations with ship in dock and with dock empty were made over identical points. Miscellaneous loose magnetic material was present in large quantities, but it is supposed that for the most part this material was undisturbed during the interval between the two series of observations. Figure 18 shows the approximate general relation of the selected points to the outline of the dock.

Before beginning the work it was determined that the needles selected for use in the dip circle would give, without correction, a value for the inclination by a single reading in the position chosen, with an accuracy better than 0°.1, and that the prime-vertical method would give a value of the magnetic meridian within 0°.1 of the true value. Compass-variometer 2 was calibrated on May 29 and again on June 6, 1919, over its extreme range at the Standardizing Magnetic Observatory of the Department of Terrestrial Magnetism. The values of horizontal intensity given in the accompanying summary of results are based on these calibrations. Complete summaries of the data obtained are given in Table 44.

TABLE 44.—*Results of Magnetic Observations Made by the Department of Terrestrial Magnetism of the Carnegie Institution of Washington to Determine the Magnetic Field Surrounding Ship A at Dry-Dock No. 1.*

[Observations with vessel in dry-dock were made May 22, 1919; observations in empty dry-dock were made May 30, 1919; observers were H. W. Fisk and H. R. Grummann; instruments were: (*a*) dip circle 241 for declination and inclination, and (*b*) compass-variometer 2 for horizontal intensity. The approximate values of the normal magnetic elements were: Declination, 8°.8 west of true north; inclination, 71°.4 north; horizontal intensity, 0.1865 c. g. s.]

Station No.	Declination referred to longitudinal axis of dock[1]			Inclination			Horizontal intensity		
	Ship	Dock	Ship-dock	Ship	Dock	Ship-dock	Ship	Dock	Ship-dock
	°	°	°	°	°	°	*c. g. s.*	*c. g. s.*	*c. g. s.*
1	−65.4	− 3.2	−62.2	59.7	71.2	−11.5	0.3944	0.1842	+0.2102
2	−14.0	− 2.4	−11.6	79.9	71.2	+ 8.7	.1489	.1808	− .0319
3	+10.5	− 3.2	+13.7	79.9	70.3	+ 9.6	.1385	.1866	− .0481
4	+64.2	− 2.8	+67.0	63.2	70.8	− 7.6	.3522	.1891	+ .1631
5	−29.3	− 4.9	−24.4	62.0	68.2	− 6.2	.3016	.2130	+ .0886
6	....	....	....	....	....	....	....	.1888	....
7	+47.2	− 3.2	+50.4	63.1	70.2	− 7.1	.4675	.1947	+ .2728
8	+28.9	− 4.8	+33.7	63.0	71.6	− 8.6	.2961	.1806	+ .1175
9	−47.3	+ 8.9	−56.2	58.2	67.4	− 9.2	.3934	.2268	+ .1666
10	−34.1	+ 4.0	−38.1	78.8	73.0	+ 5.8	.1749	.1592	+ .0157
11	+28.9	− 8.0	+36.9	79.3	71.6	+ 7.7	.1592	.1679	− .0087
12	+27.8	− 8.7	+36.5	63.2	63.4	− 0.2	.3922	.2604	+ .1318
13	− 5.3	− 2.9	− 2.4	69.0	70.6	− 1.6	.1807	.1922	− .0115
14	+ 5.8	− 0.3	+ 6.1	81.9	69.7	+12.2	.0753	.1804	− .1051
15	+ 4.3	+ 2.4	− 1.9	64.1	67.1	− 3.0	.2125	.2226	− .0101
15A	+ 2.6	+ 1.2	+ 1.4	62.9	60.8	− 3.9	.2100	.2102	− .0002
16	+ 1.6	− 2.1	+ 3.7	71.2	71.5	− 0.3	.1617	.1773	− .0156
17	−59.3	− 1.6	−57.7	68.0	70.6	− 2.6	.2048	.1915	+ .0133
18	−46.2	− 5.1	−41.1	77.0	69.2	+ 8.6	.1469	.1936	− .0467
19	+37.3	− 9.5	+46.8	82.0	71.8	+10.2	.1184	.1730	− .0546
19A	....	+ 2.4	....	....	70.9	....	....	.1748	....
20	+46.9	− 9.7	+56.6	69.5	68.1	+ 1.2	.1830	.2152	− .0322
21	− 3.5	− 3.6	+ 0.1	66.9	70.4	− 3.5	.2313	.1939	+ .0374
22	− 1.8	− 2.2	+ 0.4	68.5	71.9	− 3.4	.2135	.1784	+ .0351
23	+ 3.0	− 3.3	+ 6.3	68.9	71.2	− 2.3	.1939	.1842	+ .0097
24	− 6.2	− 0.8	− 5.4	66.7	69.9	− 3.2	.2105	.2007	+ .0098
25	−20.0	− 0.4	−19.6	72.1	71.7	+ 0.4	.1434	.1802	− .0368
26	+ 9.2	− 8.1	+17.3	71.2	71.3	− 0.1	.1465	.1830	− .0365

[1] Approximate true bearing of longitudinal axis of dock, entrance to head, is N. 5°.5 W. A minus sign (−) indicates that north end of needle points west of line of reference, and plus sign (+) that it points to east.

Another application of compass-variometer 2 to field use was for the study of the Bermuda magnetic anomaly during July to September 1922 by H. W. Fisk and his assistant, J. T. Howard. The following brief account of some of the observations is given merely to illustrate the advantages of the instrument for work of this character.

The Bermuda anomaly is very irregular, apparently consisting of two parts, a deep-seated disturbance residing in the volcanic rocks which form the base upon which the coral formation has been built, and a superimposed disturbance residing in the soil or rocks at the immediate surface of the island. For the investigation of the former, observations separated by relatively longer distances were made over the entire exposed land area of the group, using generally the regular field instruments with an abridged scheme of observations. In many cases it was desirable to examine the region around these stations to determine whether the results obtained were representative of the vicinity, or whether they were possibly affected by disturbances of the second sort arising from surface conditions. For this, compass-variometer 2 was admirably adapted and provided effective means of making the desired examination quickly and with the

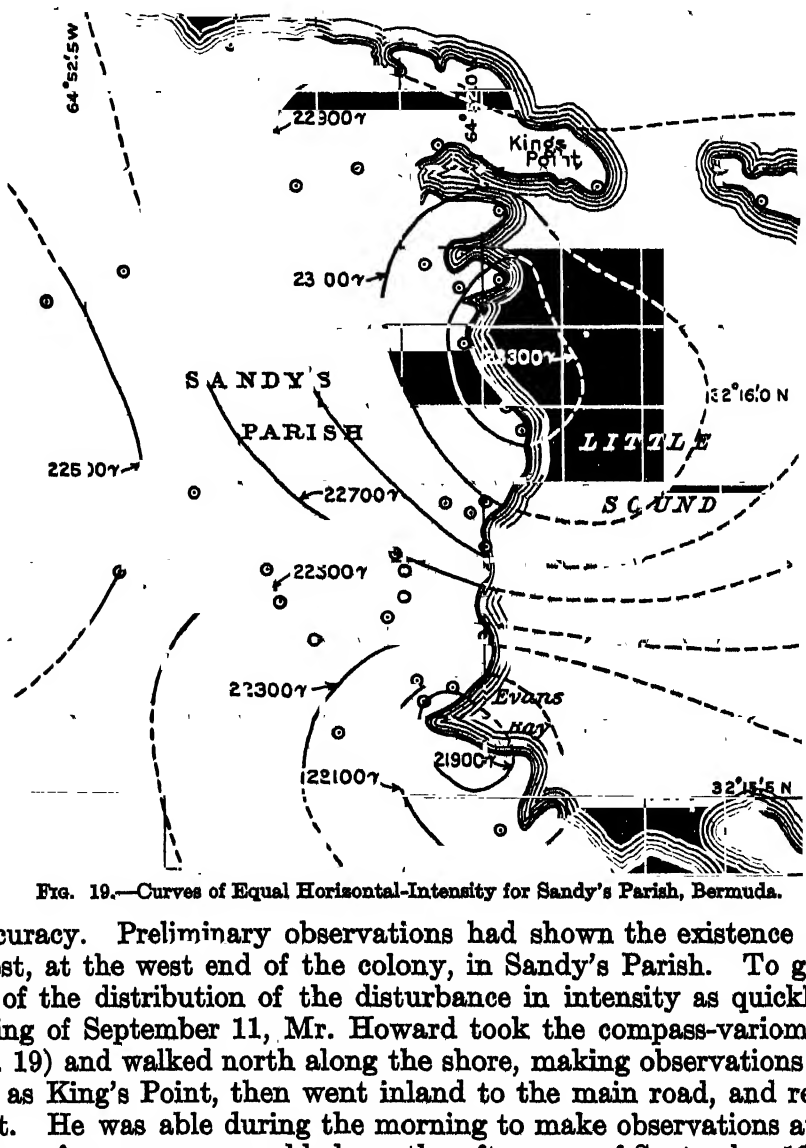


FIG. 19.—Curves of Equal Horizontal-Intensity for Sandy's Parish, Bermuda.

necessary accuracy. Preliminary observations had shown the existence of a region of special interest, at the west end of the colony, in Sandy's Parish. To gain a comprehensive idea of the distribution of the disturbance in intensity as quickly as possible, on the morning of September 11, Mr. Howard took the compass-variometer to Evans Bay (see Fig. 19) and walked north along the shore, making observations at convenient points as far as King's Point, then went inland to the main road, and returned to the starting-point. He was able during the morning to make observations at 22 points, to which number a few more were added on the afternoon of September 13, as also some repetitions for verification. Figure 19 represents the distribution of these points of observation, all of which lie within a rectangle less than a mile square. The coordinate lines of this figure are drawn at intervals of 0.1 minute, which for convenience in plotting are made of equal length in both latitude and longitude. Based on results of the

observations with the compass-variometer at these points, curves of equal horizontal intensity were constructed and are shown in the figure, the mean value of the horizontal intensity for the region being about 0.2270 c. g. s. unit. Lines of equal disturbance can not be completed for lack of observations over the sound, but sufficient were obtained to reveal a region of maximum intensity and a region of minimum intensity a little more than one-half mile apart.

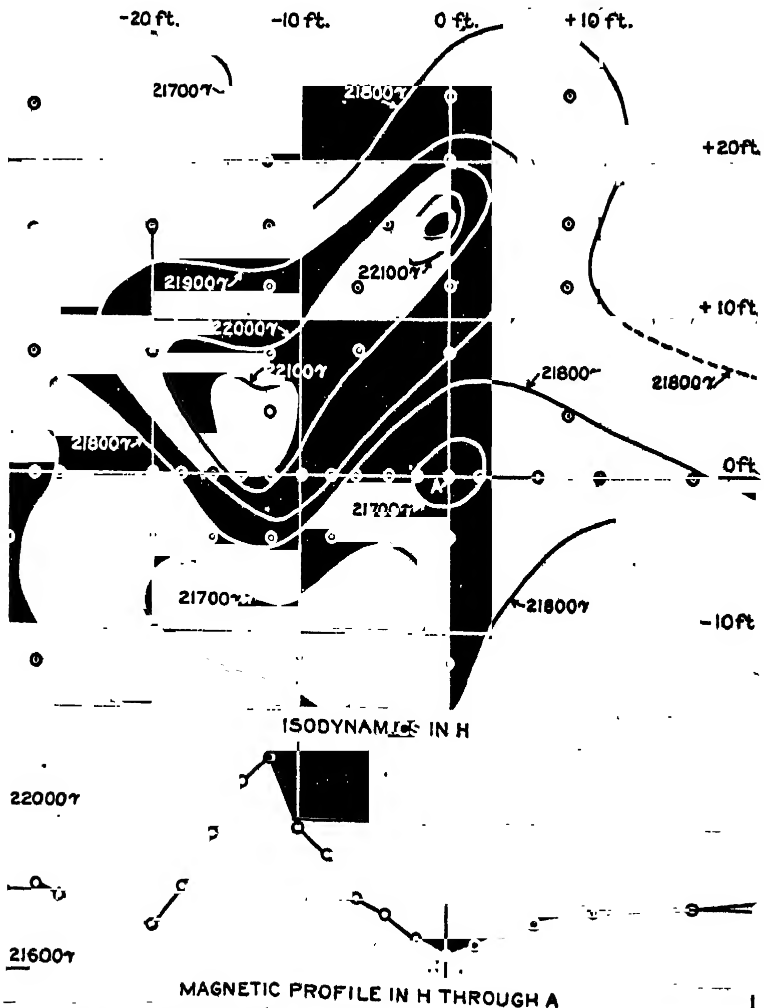


FIG. 20.—Horizontal-Intensity-Survey Results in Neighborhood of Station *A*, Paget West, Bermuda.

A detailed survey was also made on August 2 and 3 of a small area, only a few feet in extent, in the vicinity of the base-station at Mont Royal, Paget West, where there was indication of a surface disturbance. The variometer was mounted in its carrying case (see Plate 15, Fig. 8) and was placed near the ground, so that the magnetic system of the instrument was about 1 foot above the surface. Leveling was accomplished by the use of a wide board, about 3 feet long, laid on the ground and approximately leveled by means of small blocks and wedges. The instrument was placed on this board and the final leveling accomplished by means of the leveling-screws with which the carrying-case is provided. In carrying from one position to another care was exercised not to rotate the instrument about a vertical axis more than necessary in order to avoid setting up excessive motion of the liquid which was used for damping. A little time was always allowed for such currents as were unavoidably set up to die out.

Figure 20 is presented to show the disturbance near the ground, as revealed by this survey. Lines of equal horizontal intensity are drawn for each 100 gammas (1 gamma being 0.00001 C. G. S. unit), as nearly as practicable from the values obtained at the points shown by the small circles. The rapidity with which the work was done is illustrated by Table 45, which shows the observations along the base-line, from west to east through the base-station *A*.

TABLE 45.—*Compass-Variometer Survey along East-West Line through Station A, Mont Royal, Paget West, Bermuda, August 3, 1922.*

Distance	L. M. T.	Micrometer reads	Hor. int. Obs'd.	Hor. int. Corrected for D. V.	Distance	L. M. T.	Micrometer reads	Hor. int. Obs'd.	Hor. int. Corrected for D. V.
feet	*h m*	°	*c. g. s.*	*c. g. s.*	*feet*	*h m*	°	*c. g. s.*	*c. g. s.*
−20	9 24	55.60	0.21749	0.2172	− 4	10 09	55.56	0.21790	0.2177
−18	9 29	55.51	.21842	.2182	− 2	10 14	55.62	.21729	.2171
−16	9 34	55.37	.21988	.2196	A	10 27	55.66	.21688	.2167
−14	9 37	55.24	.22125	.2210	+ 2	10 33	55.63	.21718	.2170
−12	9 43	55.18	.22185	.2216	+ 6	10 40	55.65	.21698	[1] .2168
−10	9 47	55.36	.21999	.2198	+10	10 49	55.55	.21800	.2178
− 8	9 52	55.41	.21947	.2192	+16	10 54	55.54	.21811	.2180
− 6	9 59	55.52	.21831	.2181	+ 6	11 09	55.58	.21770	.2176

[1] Rejected; see repetition at 11^h09^m.

Under the column "Distance" the position of the station is shown, a negative sign indicating a station west and a positive sign a station east of station *A;* the observed horizontal intensity, *H*, is as taken from the calibration graph of the instrument and is reduced approximately for diurnal variation in the last column.

Calibration graphs were determined from observations at the Standardizing Magnetic Observatory (see p. 342) made before and after field use of the instrument. Some changes were indicated, but these were controlled through observations made at intervals in the field at stations where magnetometer observations were made. For the date of the survey at station *A* the calibration curve is represented by the equation $H = 0.22380 - 0.01076\ (R-55.00) + 0.0004185\ (R-55.00)^2$, in which *H* is expressed in C. G. S. units and *R* is the micrometer-reading.

The instrument was used further to determine whether the magnetic properties, obviously present in the soil, could be detected in masses of coral rock from which the soil has been derived. The rock is soft and easily quarried and building blocks were available for examination. The blocks, rectangular in form, about 12 by 12 by 24 inches, are relatively light and easy to handle. A column of these was built up and the compass-variometer read in various positions with respect to it; in this way relatively large masses could be brought very near the magnet-system of the instrument. No measurable difference in reading was noted that could be assigned to the presence of the rock. A further series of experiments was made, using the compass-variometer at the bottom of several of the limestone caverns, where conditions were such as to make difficult or impossible the use of a regular magnetometer; readings were made afterwards at points as nearly vertically above these cavern-stations as possible, the vertical differences varying from about 15 feet to more than 125 feet. The values obtained at the lower and at the higher stations differed very slightly and no part of the disturbance noted could be ascribed to magnetic qualities present in the coral rock.

In investigations of this kind, where many determinations of reasonable accuracy are required, observation is greatly expedited by this type of instrument. Much of the work accomplished at Bermuda would have been impracticable, if not impossible, with magnetic instruments of the ordinary type.

SUNSPOT AND ANNUAL VARIATIONS OF ATMOSPHERIC ELECTRICITY, WITH SPECIAL REFERENCE TO THE CARNEGIE OBSERVATIONS, 1915-1921

By Louis A. Bauer

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SUNSPOT AND ANNUAL VARIATIONS OF ATMOSPHERIC ELECTRICITY, WITH SPECIAL REFERENCE TO THE CARNEGIE OBSERVATIONS, 1915-1921.

By Louis A. Bauer.

The following symbols and terminology pertaining to changes in the atmospheric-electric elements are used in these investigations:

d = *solar-diurnal variation*, or the change during the solar day, for example from hour to hour;
a = *annual variation*, or the change during the year, as for example from month to month, in the daily values of the atmospheric-electric elements;
s = *solar-activity* or *sunspot variation*, i. e., the change during a sunspot cycle, from year to year, in the annual values of the atmospheric-electric elements; and
t = *long-time, more or less progressive or secular, variation.*

Corrections on account of these variations will be required in any attempt to refer the atmospheric-electric observations of the *Carnegie* to a common epoch. The variations s and t together make up the annual change, i. e., the total amount of change from year to year.

The quantity d, diurnal variation, is discussed in the report by Doctor Mauchly (pp. 388–402), and attention will, therefore, be chiefly confined here to the quantities a (annual variation) and s (sunspot variation). It will be convenient to begin with the sunspot variation. *While the term "sunspot variation" is used in this report, it should be distinctly understood that no claim is made that sunspots, rather than the unspotted areas of the Sun, are the direct cause of the variations observed. A more preferable term would be "solar-activity variation"; however, since sunspots are generally used as a measure of solar activity and the length of the solar cycle is determined from the periodicity of sunspots, it was decided to use for the present the term "sunspot variation."*

SUNSPOT VARIATION OF ATMOSPHERIC ELECTRICITY.

The question whether the annual mean values of the potential gradient of atmospheric electricity vary from year to year in correspondence with the sunspot cycle appears to have been raised first a half century ago by A. Wislizenus, M. D., on the basis of a series of observations made by him at St. Louis, Missouri, 1861–1872. This unique series was made by Doctor Wislizenus with a Dellmann electrometer, eye-readings being taken almost daily every 3 hours from 6^h to 21^h for 12 years, when his eyesight began to fail him and he was obliged to discontinue his observations. He was born on May 21, 1810, at Koenigsee, in Schwarzburg, Rudolstadt, Germany, and died on September 23, 1889, at St. Louis, Missouri.

The results of Doctor Wislizenus' observations and his discussions were published in the Transactions of the Academy of Science of St. Louis, Missouri (see particularly vol. 3, 1868–1877). The following suggestive sentence concludes his discussion: "Our present knowledge certainly warrants us to accept a near relationship between terrestrial magnetism, sunspots, and atmospheric electricity, and by more extended observations we will reach at last the final aim of all scientific research—truth."

The electrometer used by Doctor Wislizenus was calibrated by Professor F. E. Nipher when he was director of the department of physics at Washington University, St. Louis.[a] Both the electrometer and the original records of Wislizenus' observations have since been lost, as has been disclosed by correspondence with Professor Nipher, Mr. Frederick

[a] The results of the calibrations are given in *Trans. Acad. Sci., St. Louis, Missouri*, vol. v (1892), p. 304.

A. Wislizenus (son of Doctor Wislizenus), the Secretary of the Smithsonian Institution, and the Chief of the United States Weather Bureau.[a]

Doubtless owing to the fact that the observations by Wislizenus and by contemporaneous investigators were made during a period when instruments, means of control, and methods of reduction were in their earliest stages of development, the bearing of the results of these early observations on the question of a possible relationship between solar activity and atmospheric electricity was gradually lost sight of, so that in later-day treatises no mention is usually found of this important question, conceded to be of paramount importance in theories of the origin and maintenance of the Earth's negative electric charge.

Owing to unexplained changes in the atmospheric potential-gradient, which were observed aboard the *Carnegie* on her various cruises, especially since 1917, the year of maximum sunspot activity, the author was led in 1921 to reinvestigate the question of a possible relationship between solar activity and atmospheric electricity, especially as regards the potential gradient, and he has since published several papers on this subject.[b] A systematic search was made in the libraries at Washington, with the assistance chiefly of Mr. W. J. Peters, for every available series of atmospheric-electric observations during the past seven sunspot cycles. The results will be found summarized in the last two references given in footnote [b]. It had been the original intention to reproduce *in extenso* in this report the observational results at the stations where fairly long and unbroken series were found; however, in view of the general interest that has been aroused and the possibility that in the near future additional series will become available, it has finally been decided to postpone doing this and consider here only the evidence from modern series of observations particularly interesting in connection with the discussion of the observations aboard the *Carnegie*, 1915–1921.

SUNSPOTTEDNESS AND ATMOSPHERIC POTENTIAL-GRADIENT.

The distribution of first-class observatories making continuous observations of atmospheric electricity is exceedingly unsatisfactory. If we wish to utilize series at fixed stations extending over the whole of the past sunspot period, namely, 1913-1922, our investigations must be confined almost exclusively to three observatories in Western Europe, whose geographic positions and mean values of the potential-gradient, P_m, for the period, are given in Table 46. Unfortunately, as regards the continuous registrations at the Potsdam Observatory, discontinuities in the series have arisen because conditions prevailing during the war prevented the available observatory staff from obtaining during the period 1914–1919 the required control observations for reducing the observations recorded at the observatory building to volts per meter (v/m) over level ground; hence, for our present purpose it would not be safe to utilize this series.

TABLE 46.—*Geographic Positions of Atmospheric-Electric Observatories in Western Europe for the Period, 1913-1922.*

Observatory	Lat.	Long.	P_m	Director
	°	°	v/m	
Ebro (Tortosa), Spain	40.8 N	0.5 E	107	Luis Rodés, S. J.
Eskdalemuir, Scotland	55.3 N	3.2 W	258	A. Crichton Mitchell.
Kew, England	51.5 N	0.3 W	338	Charles Chree.

Table 47 contains for the period 1913–1922 the mean annual values of P at Ebro, Eskdalemuir, and Kew, for the so-called electrically-undisturbed days, which average

[a] For a discussion of Doctor Wislizenus' results in connection with observations made at Brussels from 1844 to 1877 by A. Quetelet with a Peltier electrometer, the interested reader may be referred to the article by Louis A. Bauer, on Correlations between Solar Activity and Atmospheric Electricity, published in the journal *Terrestrial Magnetism and Atmospheric Electricity*, vol. 29, (1922), pp. 161–165.

[b] See particularly *Terr. Mag.*, vol. 26 (1921), pp. 63–68; vol. 27 (1922), pp. 27–30; vol. 29 (1924), pp. 23–32, and pp. 161–186; vol. 30 (1925), pp. 17–23; and *Nature*, April 11 (1925), pp. 537–540.

about 10 per month; these are the "fine-weather" days, or days of no negative potential and no pronounced disturbances. While the region represented by these observations is not as extensive as might be desired, it extends from sunny Spain to foggy London and misty Scotland, so that the conditions under which the observations were obtained are greatly different. The average value of P, as deduced from the *Carnegie* observations and from undisturbed land stations, is about 130 v/m (volts per meter). It will be observed from the mean values in Table 47 that the station which most nearly represents normal conditions is Ebro, in Spain. The average value of P at the Kew Observatory, 336 v/m, is about 2.5 times greater than the average normal value. Chree and Watson have shown by means of special measurements of the amount of pollution (smoke and dust particles) in the air above Kew Observatory, during 1921 and 1922, that for "clean" air the average potential-gradient may be about one-half of that usually observed there, hence approaching to the normal value.[a]

TABLE 47.—*Observed and Reduced Values of Atmospheric Potential-Gradient, in Volts per Meter, at Ebro, Eskdalemuir, and Kew, for the Electrically-Undisturbed Days, 1913-1922.*

No.	Year	S	Observed P			Reduction (1918.0)			P' = Reduced P		
			Ebr.	Esk.	Kew	Ebr.	Esk.	Kew	Ebr.	Esk.	Kew
			v/m	v/m	v/m	v/m	v/m	v/m	v/m	v/m	v/m
1	1913	1.4	110	252	335	−14	0	−26	96	252	309
2	1914	9.6	109	237	345	−11	0	−20	98	237	325
3	1915	47.4	111	266	354	− 8	0	−14	103	266	340
4	1916	57.1	121	248	367	− 5	0	− 9	116	248	358
5	1917	103.9	130	287	354	− 2	0	− 3	128	287	351
6	1918	80.6	126	282	346	+ 2	0	+ 3	128	282	349
7	1919	63.6	110	248	331	+ 5	0	+ 9	115	248	340
8	1920	37.6	107	262	315	+ 8	0	+14	115	262	329
9	1921	26.1	86	[1] 240	[2] 281	+11	0	+20	97	240	[2] 301
10	1922	14.2	76	257	318	+14	0	+26	90	257	344
Mean, 1913-17		43.9	116.2	258.0	351.0	Mean, 1913–1922........			109	258	336
Mean, 1918-22		44.4	101.0	257.8	322.2						
Change in 5 years........			−15.2	− 0.2	−28.8						
t = average change per year			− 3.04	− 0.04	− 5.76						

[1] Since there were no "zero," or electrically-undisturbed days in March, the annual mean, 240, is the mean of the remaining 11 months.

[2] Affected to some extent by lessened atmospheric pollution during the coal strike in summer in England; weight 0.5.

The third column, marked S, contains the final annual values of the observed Wolfer relative sunspot numbers. Examining the observed values of P, given in the next three columns, it will be noticed that in addition to the values exhibiting a relationship with the S numbers, there is apparently a drift or long-period variation, t, which is especially pronounced at Ebro. Except in the case of Eskdalemuir, P for 1922 is distinctly less than for 1913, though the values of S are not greatly different. Some portion of t is undoubtedly to be ascribed to spurious causes and to effects from errors, of greater or lesser extent, in the reduction-factor—the factor by means of which the values of P registered at the recording station, which is usually connected with some building, are reduced to what they would be over a large level area, devoid of vegetation and structures. At Ebro the reduction-factor was determined once before the series was begun in 1910 and again in 1924, the values turning out the same within the observational error. At Kew and Eskdalemuir it is the custom to make every month frequent comparative observations at "recording station" and at "control station," and a new reduction-factor is determined from each month's comparative observations. This practice would be commendable were there definite assurance that the seasonal changes (changes in

[a] *London, Proc. R. Soc.*, A, vol. 105 (1924), pp. 311–323.

nearby vegetation, etc.) at the recording station connected with an observatory building and the control station out in the field produced identical effects at both stations.

The average value of t has been approximately determined from the two 5-year means, 1913–1917 and 1918–1922, respectively, for which the mean values of S, as will be seen from the numbers of Table 47, are about the same, 44. The last three columns contain the P' values which are the observed P values corrected, approximately, for the effect of t, i. e., the values reduced to 1918.0; the numbers in these columns are supposed to be affected only by change in sunspottedness from year to year. It would appear that P at Kew, both for 1921 and 1922, is affected by the peculiar conditions prevailing at that observatory; the value for 1921 is too low and that for 1922 is too high.

The average value of t for the three observatories is -2.95 v/m, or -1.27 per cent of P_m per annum. This is precisely the value which was obtained in a different manner in my publication of 1924.[a] There it was assumed that the observed values of P, as given in Table 47, could be represented with sufficient accuracy by the following empirical formula:

$$P-P_m=\Delta P=s(S-S_m)+t(T-T_m) \tag{1}$$

where P_m and S_m are, respectively, the mean values of the potential gradient and of the corresponding sunspot numbers for the particular series considered and T_m is the mean date of the series. The coefficient s represents the change in P corresponding to one sunspot number and t represents the cycle or intercycle effect on P, dependent, apparently, upon the average character of the particular sunspot cycle considered.

By following the method of first correcting the P values for the effect of t, we are enabled to use for the corrected or reduced values of P (the P' values) the shorter formula, with the aid of which it is more readily possible to examine into the variability of s with sunspottedness, namely,

$$P'-P'_m=\Delta P_m=s(S-S_m)=s\Delta S \tag{2}$$

Table 48 contains the values of s derived from this formula by the method of least squares, as also the values of the correlation coefficient, r. Taking first the entire series,

TABLE 48.—*Relation Between Sunspottedness and Atmospheric Potential-Gradient, 1913-1922, Based on Yearly Values in Table 47.*

No.	Observatory	T_m	S_m	P_m	s		r	Series
				v/m	*v/m*	*p. ct.*		
1	Ebro	1918.0	44.2	109	+0.38	+0.35	0.92	1913–1922
2	Eskdalemuir	"	"	258	+0.37	+0.14	0.73	" "
3	Kew	"	"	336	+0.36	+0.11	0.70	" "
4	Mean	"	"	234	+0.37	+0.20	0.78	" "
5	Eb., Esk., Kew	"	"	234	....	+0.20	0.93	" "
6	Ebro	1915.5	43.9	108	+0.32	+0.29	0.96	1913–1917
7	Eskdalemuir	"	"	258	+0.39	+0.15	0.82	" "
8	Kew	"	"	337	+0.40	+0.12	0.84	" "
9	Mean	"	"	234	+0.37	+0.19	0.87	" "
10	Eb., Esk., Kew	"	"	234	....	+0.18	1.00	" "
11	Ebro	1920.5	44.4	109	+0.52	+0.48	0.98	1918–1922
12	Eskdalemuir	"	"	258	+0.34	+0.13	0.58	" "
13	Kew	"	"	336	+0.24	+0.07	0.42	" "
14	Mean	"	"	234	+0.37	+0.23	0.64	" "
15	Eb., Esk., Kew	"	"	234	....	+0.23	0.86	" "

[a] *Terr. Mag.*, vol. 29 (1924), p. 26, Table 2, No. 8.

1913–1922, it will be seen from rows 1, 2, and 3 that there is a remarkable agreement in the value s, expressed in volts per meter, at the three different stations, in spite of the fact that the average potential-gradients differ greatly from one another. Expressed in percentage of P_m, the mean value of s (row 4) from the three observatories, +0.20 per cent, is practically the same as the mean value previously found (see reference in footnote, p. 364).

It will be noticed that the correlation coefficient r varies from 0.92 at Ebro to 0.70 at Kew; the average value for the three observatories is 0.78. Taking the mean values of P for the three observatories combined, it will be seen from row 5 that $s = +0.20$ per cent of P_m and $r = 0.93$.

Treating separately the two halves of the sunspot cycle, the increasing half, 1913–1917, and the decreasing half, 1918–1922, the quantities in rows 6–15 are obtained. It will be observed that the average percentage value of s is somewhat smaller for the increasing portion of the sunspot cycle than for the decreasing portion, though the average value of r for the former portion is larger than for the latter portion. Kew gives the smallest value of r for the latter portion. The results in rows 10 and 15 are derived from the mean values of P for the three observatories combined.

Acknowledgment should be made here of the courtesy extended by the respective observatory directors in furnishing recent atmospheric-electric results prior to regular publication.

Table 49 is similar to Table 47, except that the tabulated results apply to the six summer months, April to September. Table 50 similarly contains the results for the six consecutive winter months, October to March. The sunspot numbers S, in Tables 49 and 50, apply, respectively, to the six summer months and to the six winter months.

TABLE 49.—*Observed and Reduced Values of Atmospheric Potential-Gradient at Ebro, Eskdalemuir and Kew, for the Electrically-Undisturbed Days of the Summer Months (April to September), 1913-1922.*

No.	T_m	S_s	Observed P_s			Reduction (1918.0)			P'_s = Reduced P			P'_s in p. ct. of P_{sm}			
			Ebr.	Esk.	Kew	Ebr.	Esk.	Kew	Ebr.	Esk.	Kew	Ebr.	Esk.	Kew	Mean
			v/m	v/m	v/m	v/m	v/m	v/m	v/m	v/m	v/m	p. ct.	p. ct.	p. ct.	p. ct.
1	1913.5	0.7	99	187	255	−10	+ 3	−21	89	190	234	89	92	95	92.0
2	1914.5	10.0	96	201	261	− 8	+ 3	−17	88	204	244	88	99	99	95.3
3	1915.5	55.6	106	204	269	− 6	+ 2	−12	100	206	257	100	100	104	101.3
4	1916.5	58.0	111	211	246	− 3	+ 1	− 7	108	212	239	108	103	97	102.7
5	1917.5	117.9	117	220	266	− 1	0	− 2	116	220	264	116	107	107	110.0
6	1918.5	84.3	112	218	269	+ 1	0	+ 2	113	218	271	113	106	110	109.7
7	1919.5	73.2	100	199	230	+ 3	− 1	+ 7	103	198	237	103	96	96	98.3
8	1920.5	28.3	105	226	230	+ 6	− 2	+12	111	224	242	111	109	98	106.0
9	1921.5	28.5	91	200	[1]202	+ 8	− 3	+17	99	197	[1]219	99	96	[1]89	94.8
10	1922.5	7.8	63	198	230	+10	− 3	+21	73	195	251	73	95	102	90.0
Mean, 1913-17...		48.4	105.8	204.6	259.4	Mean for 1913-1922			100	206	247	100	100	100	100
Mean, 1918-22...		44.4	94.2	208.2	235.6										
Change in 5 years........			−11.6	+ 3.6	−23.8										
t = av. ch. per year.......			− 2.32	+ 0.72	− 4.76										

[1] Weight, 0.5.

The arrangement of Table 51 is like that of Table 48. It will be observed that generally the highest values of s and of r apply to the Ebro Observatory. By taking the mean of the values from the three observatories (last column of Table 49), while the value of s is the same as the mean from the three separate observatory values, the correlation coefficient r is invariably increased, doubtless because the disturbing effects of local influences have been reduced. Comparing the entries for Nos. 9 and 10, which apply to the increasing portion of the sunspot cycle 1913–1917, with the corresponding entries, Nos. 14 and 15, for the decreasing portion, 1918–1922, it will be seen that while the values of s are prac-

tically the same, *the correlation coefficient is considerably higher for the increasing portion of the cycle* (cf. p. 365). In the case of Eskdalemuir and Kew, r is below 0.4 for the decreasing portion of the cycle, whereas for the increasing portion it was, respectively, 0.9 and 0.8.

TABLE 50.—*Observed and Reduced Values of Atmospheric Potential-Gradient at Ebro, Eskdalemuir, and Kew, for the Electrically-Undisturbed Days of the Winter Months (October to March), 1913-1922.*

No.	T_m	S_w	Observed P_w			Reduction (1918.0)			P'_w=Reduced P_w			P'_w in p. ct. of P_{wm}			
			Ebr.	Esk.	Kew	Ebr.	Esk.	Kew	Ebr.	Esk.	Kew	Ebr.	Esk.	Kew	Mean
			v/m	v/m	v/m	v/m	v/m	v/m	v/m	v/m	v/m	p. ct.	p. ct.	p. ct.	p. ct.
1	1913.0	3.0	118	321	381	−26	−16	−46	92	305	335	79	99	80	86.0
2	1914.0	2.7	119	267	418	−21	−13	−37	98	254	381	84	82	91	85.7
3	1915.0	25.2	114	289	447	−16	−10	−27	98	279	420	84	91	100	91.7
4	1916.0	49.7	123	345	502	−11	− 6	−18	112	339	484	97	110	116	107.7
5	1917.0	68.4	140	333	440	− 5	− 3	− 9	135	330	431	116	107	103	108.7
6	1918.0	88.6	150	341	420	0	0	0	150	341	420	129	111	100	113.3
7	1919.0	70.3	119	294	455	+ 5	+ 3	+ 9	124	297	464	107	96	111	104.7
8	1920.0	50.8	115	297	361	+11	+ 6	+18	126	303	379	109	98	91	99.3
9	1921.0	32.2	95	301	404	+16	+10	+27	111	311	431	96	101	103	100.0
10	1922.0	24.9	93	310	397	+21	+13	+37	114	323	434	98	105	104	102.3
Mean, 1914-18...		46.9	129.2	315.4	445.4	Mean for 1913-1922			116	308	418	100	100	100	99.9
Mean, 1919-22...		44.6	105.5	300.5	404.2										
Change in 4.5 years......			−23.7	−14.5	−41.2										
t=av. ch. per year.......			− 5.27	− 3.22	− 9.16										

TABLE 51.—*Relation Between Sunspottedness and Atmospheric Potential-Gradient, for the Summer Months (Table 49), 1913-1922, for Ebro, Eskdalemuir, and Kew.*

No.	Observatory	T_m	S_m	P_m	s		r	Series
				v/m	v/m	p. ct.		
1	Ebro......................	1918.0	46.4	100	+0.28	+0.28	0.79	
2	Eskdalemuir..............	"	"	206	+0.18	+0.09	0.59	Summer
3	Kew......................	"	"	247	+0.21	+0.09	0.58	months,
4	Mean..............	"	"	184	+0.22	+0.15	0.65	Apr. to Sept.,
5	Eb., Esk., Kew............	"	"	184	....	+0.15	0.82	1913–1922.
6	Ebro......................	1915.5	48.4	100	+0.25	+0.25	0.96	
7	Eskdalemuir..............	"	"	206	+0.21	+0.10	0.90	Summer
8	Kew......................	"	"	248	+0.22	+0.09	0.82	months,
9	Mean..............	"	"	185	+0.23	+0.15	0.89	Apr. to Sept.,
10	Eb., Esk., Kew............	"	"	185	....	+0.15	1.00	1913-1917.
11	Ebro......................	1920.5	44.4	100	+0.34	+0.34	0.68	
12	Eskdalemuir..............	"	"	206	+0.12	+0.06	0.28	Summer,
13	Kew......................	"	"	247	+0.20	+0.08	0.39	months,
14	Mean..............	"	"	184	+0.22	+0.16	0.45	Apr. to Sept.,
15	Eb., Esk., Kew............	"	"	184	....	+0.16	0.65	1918-1922.

A comparison of the respective values of s and r in Tables 51 and 52 shows, in general, higher values for the winter months than for the summer months. The fact again appears from Table 52 that the data at Eskdalemuir and Kew are not as good for the decreasing portion as for the increasing portion of the cycle, 1913–1922. If we combine the data at the three observatories (last column of Table 50), before applying least squares, values of r from 0.8 to 1.0 are obtained, as shown in rows 5, 10, and 15 of Table 52; from the combined values of P, it will be seen from the same rows that s *and* r *for the increasing portion of the cycle are greater than for the decreasing portion.*

TABLE 52.—*Relation Between Sunspottedness and Atmospheric Potential-Gradient for the Winter Months (Table 50), 1913-1922, for Ebro, Eskdalemuir, and Kew.*

No.	Observatory	T_m	S_m	P_m	s		r	Series
				v/m	v/m	p. ct.		
1	Ebro	1917.5	41.6	116	+0.58	+0.50	0.93	
2	Eskdalemuir	"	"	308	+0.59	+0.19	0.63	Winter
3	Kew	"	"	418	+0.82	+0.20	0.55	months, Oct. to Mar.,
4	Mean	"	"	281	+0.66	+0.30	0.70	1912-1922.
5	Eb., Esk., Kew	"	"	281	....	+0.30	0.91	
6	Ebro	1915.0	29.8	107	+0.56	+0.52	0.93	
7	Eskdalemuir	"	"	301	+0.94	+0.31	0.77	Winter
8	Kew	"	"	410	+1.50	+0.37	0.78	months, Oct. to Mar.,
9	Mean	"	"	273	+1.00	+0.30	0.83	1912-1917.
10	Eb., Esk., Kew	"	"	273	....	+0.38	0.97	
11	Ebro	1920.0	53.4	125	+0.53	+0.42	0.91	
12	Eskdalemuir	"	"	315	+0.18	+0.06	0.27	Winter
13	Kew	"	"	426	+0.08	+0.02	0.07	months, Oct. to Mar.,
14	Mean	"	"	289	+0.26	+0.17	0.42	1918-1922.
15	Eb., Esk., Kew	"	"	289	....	+0.17	0.81	

Table 53 groups the monthly values of S and P for the 5 years of low sunspottedness, 1913, 1914, 1920–1922, for the five years of high sunspottedness, 1915–1919, and for the entire cycle, 1913–1922, at the three observatories, Ebro, Eskdalemuir, and Kew. Comparing the monthly values of P in the sixth and eleventh columns, it will be noticed that for every month, excepting August, the mean values of P for the three observatories are greater in the case of high sunspottedness than the corresponding ones for low sunspottedness.

In Table 54 there will be found assembled the mean results from Table 53. The column T_m, shows that the mean epochs for the 5 years of low and high sunspottedness, respectively, are the same within a year, so that it will not be necessary for our present purpose to take into account any effect, t, from a possible long-time change, or a drift ascribable to some instrumental or other cause. The values of s in row 4 are about the same for each observatory, if expressed in volts per meter. The percentage changes

TABLE 53.—*Mean Values of P for 5 Years of Low, 5 Years of High Sunspottedness, and for Entire Cycle of 1913-1922, at Ebro, Eskdalemuir, and Kew.*

Month	Low sunspottedness, 5 years					High sunspottedness, 5 years					Entire 10 years				
	S	Ebr.	Esk.	Kew	Mean	S	Ebr.	Esk.	Kew	Mean	S	Ebr.	Esk.	Kew	Mean
		v/m	v/m	v/m	v/m		v/m	v/m	v/m	v/m		v/m	v/m	v/m	v/m
Jan.	19.9	108	311	427	282	57.4	131	336	539	335	38.7	120	323	483	309
Feb.	22.8	106	316	434	285	62.9	124	363	461	316	42.8	115	340	448	301
Mar.	31.0	103	266	339	236	67.9	134	291	466	297	49.4	119	279	403	267
Apr.	15.3	93	218	336	216	64.0	128	257	362	249	39.6	110	238	349	232
May	13.7	98	214	244	185	77.3	111	199	305	205	45.5	104	207	274	195
Jun.	17.9	*81*	184	*179*	148	84.4	107	*175*	228	170	51.2	94	*179*	203	159
Jul.	17.5	*81*	*169*	189	*146*	83.4	100	199	195	165	50.5	*91*	184	*198*	*156*
Aug.	11.3	92	207	221	173	86.0	*99*	197	*187*	*161*	48.6	96	202	204	167
Sep.	14.5	94	222	244	187	71.7	111	235	259	202	43.1	102	229	252	194
Oct.	17.1	93	273	321	229	62.8	122	264	326	237	40.0	108	269	324	234
Nov.	13.9	104	308	427	280	66.0	127	350	421	299	39.9	115	329	424	289
Dec.	18.8	115	316	462	298	62.2	140	328	457	308	40.5	128	322	460	303
Mean	17.9	97.4	250.4	318.6	222.1	70.5	119.5	266.2	350.5	245.3	44.2	108.5	258.3	334.7	233.8

given in row 5 show considerable variation at the three observatories; the mean value of s as derived from the mean values of P_m for the three observatories, given in the column before the last, is $+0.19$ per cent of P_m (234 v/m), which agrees well with the value obtained before (see Table 48, Nos. 4 and 5).

TABLE 54.—*Summary of Mean Results in Table 53 and Deduced Average Change (s) in P for One Sunspot Number.*

No.	Quantity	Mean Epoch	Mean Sunspot	Observed P_m Ebr.	Observed P_m Esk.	Observed P_m Kew	Observed P_m Mean	Period
		T_m	S_m	v/m	v/m	v/m	v/m	
1	Low sunspottedness, 5 years.......	1918.5	17.9	97.4	250.4	318.6	222.1	1913–14; 1920–22
2	High sunspottedness, 5 years.......	1917.5	70.5	119.5	266.2	350.5	245.3	1915–1919
3	High—Low...............................		+52.6	+22.1	+15.8	+31.9	+23.2	
4	s=av. ch. in P for 1 sunspot number..........................			+ 0.42	+ 0.30	+ 0.61	+ 0.44	1913–1922
5	Value of s in per cent of P_m..........................			+ 0.39	+ 0.12	+ 0.18	+ 0.19	1913–1922

SUNSPOTTEDNESS AND DIURNAL VARIATION OF ATMOSPHERIC POTENTIAL-GRADIENT.

Let us next examine into the relationship between sunspottedness and some measure of the diurnal variation of the atmospheric potential-gradient, P. Tables 55, 56, and 57 contain the diurnal-variation quantities, for the mean of year, 1912–1923, at the three observatories, Ebro, Eskdalemuir, and Kew. In the bottom rows will be found the average departures, regardless of sign, of the hourly values from the mean value of P given for the respective year. A plus tabular quantity signifies a higher hourly value of P than for the mean of day.

TABLE 55.—*Diurnal Variation of Atmospheric Potential-Gradient (P) at Ebro Observatory for the Selected Quiet Days per Month, 1912–1923.*

G. M. T.	1912	1913	1914	1915	1916	1917	1918	1919	1920	1921	1922	1923
h	v/m	v/m	v/m	v/m	v/m	v/m	v/m	v/m	v/m	v/m	v/m	v/m
1	−19	−22	−20	−21	−21	−26	−25	−21	−22	−13	−12	−15
2	−23	−27	−26	−25	−27	−30	−26	−25	−26	−18	−15	−18
3	−24	*−28*	−27	−28	*−28*	−32	−29	−28	−28	−18	*−17*	−21
4	*−26*	−27	*−28*	*−30*	−26	*−33*	*−29*	*−30*	*−29*	*−19*	*−17*	*−22*
5	−23	−26	−23	−27	−23	−30	−27	−27	−28	*−19*	−16	−20
6	−14	−18	−17	−16	−14	−19	−19	−18	−22	−14	−10	−14
7	− 1	− 3	− 4	− 6	− 1	− 2	− 9	− 3	−10	− 4	− 1	− 1
8	+12	+13	+10	+ 8	+14	+13	+11	+12	+ 7	+ 7	+ 5	+ 9
9	+12	+14	+11	+14	+14	+16	+15	+13	+16	+ 8	+ 5	+ 7
10	+ 6	+ 8	+ 8	+10	+ 3	+ 5	+11	+12	+17	+ 7	+ 1	0
11	+ 3	+ 5	+ 7	+ 5	− 1	0	+ 5	+ 6	+ 9	+ 3	0	− 2
12	+ 4	+ 6	+ 9	+ 5	+ 2	+ 4	+ 5	+ 5	+ 9	+ 4	+ 4	+ 3
13	+ 6	+ 8	+11	+ 4	+ 6	+ 8	+ 9	+ 7	+10	+ 6	+ 5	+ 5
14	+ 3	+ 6	+ 9	+ 4	+ 4	+ 9	+ 9	+ 7	+ 7	+ 4	+ 3	+ 4
15	+ 1	+ 6	+ 6	+ 1	+ 5	+12	+ 6	+ 3	+ 5	+ 3	+ 4	+ 6
16	0	+ 2	+ 2	0	− 1	+ 8	+ 4	+ 2	+ 3	0	+ 3	+ 4
17	+ 1	+ 5	+ 3	+ 4	+ 2	+12	+ 9	+ 4	+ 5	+ 2	+ 5	+ 8
18	+12	+14	+10	+17	+14	+23	+20	+12	+20	+12	+10	+16
19	+26	+28	+26	+38	+31	+41	+35	+23	+35	+25	+16	+27
20	+29	+31	+34	+39	+36	+40	+34	+33	+36	+27	+19	+27
21	+18	+19	+23	+27	+19	+20	+22	+21	+21	+18	+18	+17
22	+ 9	+ 5	+ 9	+ 8	+ 4	+ 1	+ 5	+ 7	+ 3	+ 5	+ 5	+ 5
23	− 2	− 7	− 7	− 7	− 6	−13	−10	− 4	−12	− 4	− 5	− 5
24	−13	−15	−17	−16	−16	−24	−19	−13	−19	−11	−10	−10
A. D........	12.0	14.3	14.5	15.0	13.2	17.5	16.4	14.0	16.6	10.5	8.8	11.1
P_m..........	113	110	109	111	121	130	126	110	107	85	76	91

TABLE 56.—*Diurnal Variation of Atmospheric Potential-Gradient (P) at Eskdalemuir Observatory for Selected Quiet Days (0, a), 1912-1923.*

G. M. T.	1912	1913	1914	1915	1916	1917	1918	1919	1920	1921	1922	1923
h	*v/m*	*v/m*	*v/m*	*v/m*	*v/m*	*v/m*	*v/m*	*v/m*	*v/m*	*v/m*	*v/m*	*v/m*
1	−11	− 7	+ 2	− 3	+ 8	−19	+ 6	+14	+18	+ 4	−15	+16
2	−18	− 6	−14	− 9	+ 2	−23	+10	− 6	− 2	− 7	−30	−12
3	−21	−13	−21	−25	− 4	−23	−11	−15	−17	−15	−35	−28
4	−19	− 7	−27	−18	− 9	−29	−24	−22	−13	−21	−31	−17
5	−10	−10	−27	−15	−18	−32	−24	− 9	−16	−22	−31	−24
6	−17	− 8	−21	−10	−19	−32	−15	− 3	−19	−19	−25	− 8
7	+ 3	+ 5	−11	− 2	−31	*−40*	−12	−19	−12	−11	− 7	− 3
8	+ 2	0	− 8	−12	−24	−29	−19	−27	− 9	−11	− 9	− 6
9	− 2	− 4	−16	−30	−24	−23	−36	−32	−17	−23	−25	−26
10	−18	−13	−21	−30	− 2	−20	−53	−36	−36	−43	−45	−43
11	−35	−16	−25	−38	−18	−20	−54	*−37*	−46	−44	*−48*	*−52*
12	*−49*	−24	−24	−40	−26	−29	*−61*	−34	*−51*	*−48*	−41	−33
13	−40	−30	*−30*	*−42*	−39	−19	−56	−30	*−51*	−45	−37	−50
14	−27	*−37*	−27	−34	−32	−15	−49	−22	−44	−36	−31	−32
15	−20	−24	−17	−34	*−40*	− 1	−32	−19	−28	−25	−12	−31
16	−19	− 7	+ 1	−17	−25	+14	−12	−13	−25	− 7	+ 1	−31
17	− 2	+ 3	+ 3	+ 8	−20	+32	+17	+ 2	− 7	+14	+26	−10
18	+39	+10	+14	+28	+13	+51	+63	+21	+34	+34	+54	+25
19	+58	+30	+36	+49	+48	+43	+75	+46	+60	+59	+82	+72
20	+52	+52	+51	+72	+71	+60	+74	+67	+67	+86	+83	+84
21	+69	+53	+66	+78	+62	+61	+78	+79	+72	+78	+93	+79
22	+64	+33	+53	+66	+72	+51	+70	+49	+67	+62	+58	+69
23	+29	+23	+44	+40	+46	+38	+48	+26	+44	+33	+25	+47
24	− 5	− 2	+19	+15	+ 5	+ 4	+18	+19	+33	+ 6	− 4	+17
A. D.	26.2	17.4	24.1	29.8	27.4	29.5	38.2	27.0	32.8	31.4	35.3	34.0
P_m	242	252	237	266	256	287	282	248	262	240	257	278

TABLE 57.—*Diurnal Variation of Atmospheric Potential-Gradient (P) at Kew Observatory for the 10 Selected Quiet Days per Month, 1912-1922.*

G. M. T.	1912	1913	1914	1915	1916	1917	1918	1919	1920	1921	1922
h	*v/m*	*v/m*	*v/m*	*v/m*	*v/m*	*v/m*	*v/m*	*v/m*	*v/m*	*v/m*	*v/m*
1	−53	−50	−41	−36	−42	−53	−65	−41	−34	−53	−49
2	−71	−64	−67	−63	−63	−64	*−73*	−59	−56	−67	−78
3	−77	*−80*	*−84*	−75	−71	−76	−72	−65	*−68*	*−78*	−81
4	*−79*	*−80*	−79	−79	*−75*	*−82*	−71	*−71*	−63	*−78*	*−82*
5	−66	−67	−68	*−84*	−69	−66	−59	−68	−53	−66	−65
6	−44	−46	−51	−63	−44	−36	−29	−35	−23	−39	−38
7	+ 2	+ 1	0	−25	+ 2	+12	+18	+14	+26	+ 1	+ 8
8	+52	+42	+42	+28	+63	+52	+48	+53	+50	+34	+49
9	+70	+57	+50	+56	+62	+54	+62	+51	+54	+51	+61
10	+48	+40	+30	+41	+43	+35	+44	+47	+34	+42	+49
11	+ 8	+ 8	+ 7	+15	+ 8	+13	+24	+25	+ 9	+29	+15
12	−13	−11	− 6	−18	−15	− 2	+ 9	0	− 9	+19	+ 2
13	−12	−25	−34	−27	−36	−11	− 3	−12	−22	0	−13
14	−14	−29	−39	−28	−40	−19	−17	−16	−29	− 7	−17
15	− 9	−18	−27	−17	−29	−13	−20	−11	−26	− 3	−15
16	+ 2	− 2	−15	−10	− 8	− 2	−10	+ 1	− 6	+ 6	+ 2
17	+30	+27	+10	+19	+10	+22	+11	+13	+12	+22	+25
18	+51	+62	+45	+73	+52	+62	+50	+30	+33	+44	+42
19	+59	+80	+75	+89	+67	+66	+60	+44	+49	+52	+54
20	+60	+73	+85	+81	+76	+72	+66	+49	+50	+54	+62
21	+52	+63	+78	+74	+72	+52	+51	+49	+47	+40	+53
22	+34	+41	+59	+51	+50	+27	+26	+28	+33	+28	+31
23	+ 3	+10	+32	+19	+12	−11	−10	0	+ 8	− 3	+10
24	−38	−31	− 8	−21	−24	−34	−40	−26	−16	−28	−26
A. D.	39.2	42.0	42.8	45.5	43.0	39.0	39.1	33.7	33.8	35.2	38.6
P_m	300	335	345	354	367	354	346	331	315	281	318

TABLE 58.—*Observed and Reduced Values of Fourier Amplitudes of Solar-Diurnal Variation (d) of Atmospheric Potential-Gradient at Ebro, Eskdalemuir, and Kew, for the Electrically-Undisturbed Days, 1913-1922.*

FORMULAE

$d = a_1 \cos\theta + b_1 \sin\theta + a_2 \cos 2\theta + b_2 \sin 2\theta + \ldots = c_1 \sin(\theta+\phi_1) + c_2 \sin(2\theta+\phi_2) + \ldots$ θ is counted from 0^h, midnight G. M. T., at the rate of 15° per hour.

$c_r = \sqrt{c_1^2 + c_2^2 + c_3^2 + c_4^2}$

No.	Year	S	Observed c_r			Reduction (1918.0)			c'_r = Reduced c_r		
			Ebr.[1]	Esk.[2]	Kew[2]	Ebr.	Esk.	Kew	Ebr.	Esk.	Kew
			v/m	v/m	v/m	v/m	v/m	v/m	v/m	v/m	v/m
1	1913	1.4	24.0	32.2	69.7	−3.2	+10.9	−8.8	20.8	43.1	60.9
2	1914	9.6	24.0	40.9	71.8	−2.5	+ 8.5	−6.9	21.5	49.4	64.9
3	1915	47.4	26.6	51.2	74.2	−1.8	+ 6.0	−4.9	24.8	57.2	69.3
4	1916	57.1	23.8	47.7	70.1	−1.1	+ 3.6	−2.9	22.7	51.3	67.2
5	1917	103.9	29.9	47.0	65.9	−0.4	+ 1.2	−1.0	29.5	48.2	64.9
6	1918	80.6	26.8	63.5	64.6	+0.4	− 1.2	+1.0	27.2	62.3	65.6
7	1919	63.6	23.9	45.8	57.0	+1.1	− 3.6	+2.9	25.0	42.2	59.9
8	1920	37.6	27.2	54.6	54.8	+1.8	− 6.0	+4.9	29.0	48.6	59.7
9	1921	26.1	18.1	54.7	[3] 60.5	+2.5	− 8.5	+6.9	20.6	46.2	[3] 67.4
10	1922	14.2	14.4	60.7	65.4	+3.2	−10.9	+8.8	17.6	49.8	74.2
Mean, 1913-17....		43.9	25.7	43.8	70.3	Mean, 1913–1922.........			23.9	49.8	65.4
Mean, 1918-22.....		44.4	22.1	55.9	60.5						
Change in 5 years...........			− 3.6	+12.1	− 9.8						
t_d = av. ch. per year.........			− 0.72	+ 2.42	− 1.96						

[1] Dependent on momentary hourly values and no correction for a supposed non-cyclic change was applied.

[2] Corrections to the deduced diurnal-variations were applied by the respective observatory directors for a supposed linearly progressing non-cyclic change and the computed amplitudes were corrected to allow for the fact that the hourly values are 60-minute means.

[3] For same reason as given in corresponding footnote of Table 47, this value may have been affected by the coal strike in England in the summer of 1921, hence weight given 0.5.

TABLE 59.—*Relation between Sunspottedness and Combined Fourier Amplitudes (c_r) of Diurnal Variation of Atmospheric Potential-Gradient, 1913-1922, at Ebro, Eskdalemuir, and Kew.*

No.	Observatory	T_m	S_m	c_{rm}	s		r	Series
				v/m	v/m	p. ct.		
1	Ebro....................	1918.0	44.2	23.9	+0.09	+0.38	+0.77	1913-1922
2	Eskdalemuir.............	"	"	49.8	+0.06	+0.13	+0.35	" "
3	Kew.....................	"	"	65.3	−0.01	−0.20	−0.10	" "
4	Mean.............	"	"	46.3	+0.05	+0.10	+0.34	" "
5	Eb., Esk., Kew...........	"	"	46.3	....	+0.17	+0.71	" "
6	Ebro....................	1915.5	43.9	23.9	+0.08	+0.33	+0.93	1913-1917
7	Eskdalemuir.............	"	"	49.8	+0.04	+0.07	+0.30	" "
8	Kew.....................	"	"	65.4	+0.03	+0.05	+0.42	" "
9	Mean.............	"	"	46.4	+0.05	+0.15	+0.55	" "
10	Eb., Esk., Kew...........	"	"	46.4	....	+0.15	+0.79	" "
11	Ebro....................	1920.5	44.4	23.9	+0.12	+0.50	+0.69	1918-1922
12	Eskdalemuir.............	"	"	49.8	+0.13	+0.26	+0.46	" "
13	Kew.....................	"	"	65.1	−0.12	−0.19	−0.54	" "
14	Mean.............	"	"	46.3	+0.04	−0.19	+0.20	" "
15	Eb., Esk., Kew...........	"	"	46.3	....	+0.20	+0.65	" "

As a first measure of the diurnal-variation activity, the quantity c_r, or the combined amplitude of the first four terms of the Fourier series, is taken and given in Table 58. The method of allowing for possible drift in the annual values, or the effect of the t-variation is the same as that adopted for Table 47. Table 59 is similar to Table 48, and will not require, therefore, special explanation. It will be observed for Eskdalemuir, and especially

for Kew, that the values of s and r are greatly reduced and even reversed for Kew (see entries Nos. 3 and 13). This seems to appear to be due chiefly to local disturbing influences at these observatories as the result of which the amplitude of the 12-hour, or local, wave is, on the average, two times and more that of the 24-hour wave. At Ebro, the amplitude of the 12-hour wave is only about 0.8 that of the 24-hour wave. If before applying least squares we obtain the mean values of c_r for the three observatories, reducing in this manner the effect of local influences, values of s and r are found, as will be seen from Nos. 5, 10, and 15, that compare favorably with the corresponding entries in Table 48.

Table 60 contains the Fourier amplitudes only for the 24-hour wave, arranged in a similar manner to Table 58. Taking the mean values for the three observatories, the resulting values of s and r for the various series are found in good agreement, as will be seen from Table 61.

TABLE 60.—*Observed and Reduced Values of Fourier Amplitudes (c_1) of 24-Hour Wave of Diurnal Variation (d) of Atmospheric Potential-Gradient at Ebro, Eskdalemuir, and Kew, for the Electrically-Undisturbed Days, 1913-1922.*

FORMULA

$d = a_1 \cos\theta + b_1 \sin\theta + \ldots = c_1 \sin(\theta + \phi_1) \ldots$ θ is counted from 0^h, midnight, G. M. T.

No.	Year	S	Observed c_1			Reduction (1918.0)			c_1' = Reduced c_1		
			Ebr.[1]	Esk.[2]	Kew[2]	Ebr.	Esk.	Kew	Ebr.	Esk.	Kew
			v/m	*v/m*	*v/m*	*v/m*	*v/m*	*v/m*	*v/m*	*v/m*	*v/m*
1	1913	1.4	18.0	22.4	38.8	−2.0	+10.8	−5.2	16.0	33.2	33.6
2	1914	9.6	18.0	34.0	36.2	−1.5	+ 8.4	−4.1	16.5	42.4	32.1
3	1915	47.4	18.7	42.0	44.7	−1.1	+ 6.0	−2.9	17.6	48.0	41.8
4	1916	57.1	16.4	38.4	30.7	−0.7	+ 3.8	−1.9	15.7	42.2	28.8
5	1917	103.9	23.4	43.1	37.6	−0.2	+ 1.2	−0.6	23.2	44.3	37.0
6	1918	80.6	20.8	56.4	34.9	+0.2	− 1.2	+0.6	21.0	55.2	35.5
7	1919	63.6	17.3	40.6	30.0	+0.7	− 3.8	+1.9	18.0	36.8	31.9
8	1920	37.6	20.9	47.3	21.7	+1.1	− 6.0	+2.9	22.0	41.3	24.6
9	1921	26.1	13.1	46.3	[3]40.3	+1.5	− 8.4	+4.1	14.6	37.9	[3]44.4
10	1922	14.2	11.3	49.2	36.4	+2.0	−10.8	+5.2	13.3	38.4	41.6
Mean, 1913-17....		43.9	18.9	36.0	37.6	Mean, 1913-1922.........			17.8	42.0	34.6
Mean, 1918-22....		44.4	16.7	48.0	31.8						
Change in 5 years...........			− 2.2	+12.0	− 5.8						
t_d=av. ch. per year..........			− 0.44	+ 2.40	− 1.16						

[1] Dependent on momentary hourly values and no correction for a supposed non-cyclic change was applied.

[2] Corrections to the deduced diurnal-variations were applied by the respective observatory directors for a supposed linearly progressing non-cyclic change and the computed amplitudes were corrected to allow for the fact that the hourly values are 60-minute means.

[3] For same reason as given in corresponding footnote of Table 47, this value may have been affected by the coal strike in England in the summer of 1921, hence weight given 0.5.

If we take as measures of the diurnal variation of the potential gradient the *average departures*, given in Tables 55, 56, and 57, and form the triennial means 1912–1923, as described on page 380 for the three observatories combined, then the data (3) given in Table 71 are found. From these quantities the values of $s = +0.036$ v/m $= +0.13$ per cent of the average departure (27.4 v/m) and of $r = +0.77$ result.

TABLE 61.—*Relation Between Sunspottedness and Fourier Amplitude (c_1) of 24-Hour Wave of Diurnal Variation of Atmospheric Potential-Gradient, 1913-1922, for Ebro, Eskdalemuir, and Kew.*

No.	Observatory	T_m	S_m	c_{1m}	s	r	Series
				v/m	*p. ct.*		
1	Eb., Esk., Kew...........	1918.0	44.2	31.5	+0.21	0.68	1913–1922
2	Do..................	1915.5	43.9	31.5	+0.20	0.71	1913–1917
3	Do..................	1920.5	44.4	31.4	+0.22	0.64	1918–1922

SUNSPOTTEDNESS AND ANNUAL VARIATION OF ATMOSPHERIC POTENTIAL-GRADIENT.

Table 62 contains the mean annual variation of the potential gradient P for the three observatories Ebro, Eskdalemuir, and Kew combined, and for the electrically-undisturbed days, 1913–1923. The average departures and ranges are given in the bottom rows. If we work with the triennial means, then the value of s is found to be +0.12 v/m or +0.24 per cent of the mean value of the average departure (51.2 v/m), and r is 0.63.

If we determine the Fourier coefficients of the annual variation, then for the predominant wave, the 12-month one, it is found that for the mean of the three observatories, $s = +0.20$ v/m or +0.25 per cent of the mean amplitude (80 v/m), and r is 0.70.

TABLE 62.—*Mean Annual Variation of P for Ebro, Eskdalemuir, and Kew, 1912-1923.*

Month	1912	1913	1914	1915	1916	1917	1918	1919	1920	1921	1922	1923
	v/m	*v/m*	*v/m*	*v/m*	*v/m*	*v/m*	*v/m*	*v/m*	*v/m*	*v/m*	*v/m*	*v/m*
Jan.	+110	+ 93	+ 97	+ 53	+ 62	+ 81	+125	+131	+ 18	+ 14	+ 78	+ 63
Feb.	+ 43	+ 92	+ 27	+ 44	+ 71	+159	+ 22	+ 57	+ 43	+ 81	+ 75	+ 14
Mar.	− 38	+ 3	− 26	+ 14	+138	+ 18	+ 73	+ 15	0	+ 22	+ 71	+ 39
Apr.	− 20	− 26	+ 17	+ 1	+ 9	+ 19	+ 8	− 19	− 35	+ 6	+ 4	+ 23
May	− *71*	− 27	− 38	− 48	− 70	− 42	− 27	− 15	− 28	− 50	− 42	− 39
Jun.	− 69	− *77*	− *87*	− 41	− *99*	− 88	− 59	− *91*	− *75*	− 52	− 80	− *81*
Jul.	− 34	− 60	− 81	− *90*	− 74	− 81	− *91*	− 65	− 78	− *73*	− *91*	− 26
Aug.	− 48	− 76	− 45	− 86	− 69	− *95*	− 83	− 86	− 25	− 43	− 55	− 65
Sep.	+ 27	− 46	− 32	− 42	− 33	− 45	− 57	− 42	− 19	− 19	− 60	− 30
Oct.	+ 40	− 7	− 39	+ 4	− 46	+ 5	+ 2	− 2	+ 70	− 28	+ 40	− 32
Nov.	+ 31	+ 15	+ 66	+122	+ 14	− 6	+ 77	+ 61	+ 68	+102	+ 39	+ 85
Dec.	+ 30	+116	+142	+ 74	+ 94	+ 80	+ 13	+ 54	+ 56	+ 42	+ 28	+ 47
A. D.	46.8	53.2	58.1	52.4	64.9	59.9	53.1	53.2	42.5	44.3	54.8	45.3
Range	181	193	229	212	237	254	216	222	145	175	169	166

SUNSPOT VARIATION OF ATMOSPHERIC POTENTIAL-GRADIENT OBSERVED ON THE CARNEGIE, 1915–1921.

For determining the possible existence of a relationship between sunspottedness and the atmospheric potential-gradients observed aboard the *Carnegie*, we have available observations made on 843 days during the period 1915–1921, in all parts of the various oceans. On 59 of these days the daily value of P was determined from the series for diurnal variation; the values of P as observed on the balance of available days (784) at times given in the "Table of Results" (pp. 212–265) were reduced to mean of day by Doctor Mauchly, with the aid of the 59 diurnal-variation series, in the manner described by him on pages 401 to 402. The geographical distribution of the stations is such as to minimize any effect inherent in the mean values of P, because of annual variation. The mean values of P, as also of the corresponding Wolfer sunspot number S, for the various groups, are given in Table 63.

TABLE 63.—*Group Values of the Atmospheric Potential-Gradient (P) from Observations Aboard the Carnegie, 1915-1921.*

Group	No. of days	*T*	*P*	*S*
			v/m	
I	169	1915.6	137	44.6
II	172	1916.6	151	60.5
III	62	1917.6	150	103.9
IV	60	1918.3	136	75.0
V	77	1919.9	135	37.1
VI	170	1920.6	111	37.4
VII	133	1921.4	104	24.0

In addition to an effect, s, that may be attributed to sunspottedness, there also appears an effect, t, to be ascribed either to natural causes or even possibly to instrumental ones, in spite of the special care taken in the control of the reduction-factor by those concerned. Accordingly formula (1),

$$P-P_m=\Delta P=s(S-S_m)+t(T-T_m)$$

as explained on page 364 is used. The values of s and t, and of s' derived by omitting the t-term, and the correlation coefficients for the two cases, are given in Table 64.

TABLE 64.—*Relation Between Sunspottedness and Atmospheric Potential-Gradient Observed Aboard the Carnegie in All Oceans, 1915-1921.*

Source	T_m	S_m	P_m	s		t		r_s	s'		r'_s
			v/m	v/m	p. ct.	v/m	p. ct.		v/m	p. ct.	
843 Observations, *Carnegie*, 1915-1921.....	1918.6	54.6	132	+0.29	+0.22	−4.95	−3.75	0.70	+0.49	+0.37	0.74

It will be observed that the value of s, +0.22 per cent of P, derived from the ocean observations, is about the same magnitude and of the same sign as the mean value deduced from the continuous series of observations at the observatories, Ebro, Eskdalemuir, and Kew, for the cycle 1913–1922 (see Table 48, Nos. 5, 10, and 15). The correlation coefficient 0.70 for the ocean observations is also satisfactory. If the t-term is not used, then the resulting value of s (s′) is +0.37 per cent of the mean value of P (132 v/m), and the correlation coefficient is 0.74.

If we use only the group values of P derived from the 59 diurnal-variation series and given in Table 68, then the following values are found by the method of least squares if formula (1) is used: $s=+0.62$ v/m $=+0.50$ per cent of P (126 v/m); $t=-5.12$ v/m $=-4.06$ per cent of P; and $r=0.77$. These values are in good agreement, as will be seen from Tables 70 and 72 with the corresponding ones at the Ebro Observatory, where the average value of P does not greatly differ from the average value for the ocean observations.

Effect of applying corrections because of variations.—It will be of interest to ascertain what improvement results in the observed values of the atmospheric potential-gradient, P, if corrections are applied because of the variations s (sunspot), t (long-time or progressive), and a (annual variation). Examining the 59 daily mean values of P, given in the sixth column of Table 65, it will be found that the values vary from 53 (No. 57) to 233 (No. 27), hence show a range of 180 v/m; the average departure, D, of the daily P values from the mean of all (124) is 26.8 v/m. If the observed values of P are referred, with the aid of the values of s and t in Table 64, to the epoch 1918.5 and to the sunspot number 55, then the values of P_r, given in the last column of Table 65, are obtained; these values vary from 80 (No. 57) to 214 (No. 27), hence show a reduced range of 134 v/m. The average departure, D, is now 20.5 v/m. Applying next the annual variation, a, as derived from Table 74, the finally-corrected values of P vary from 83 (No. 31) to 186 (No. 27), hence show a range of 103 v/m; the average departure has now been reduced from 26.8 v/m, for the directly observed values of P, to 17.2 v/m for the finally-corrected values. *The application of the various corrections resulting from the variations discussed in this report appears, therefore, to be justified.*

SUNSPOT VARIATION OF DIURNAL VARIATION OF ATMOSPHERIC POTENTIAL-GRADIENT OBSERVED ON THE CARNEGIE, 1915–1921.

Owing to the zeal and enthusiasm of the observing staff of the *Carnegie*, 59 complete series of approximately hourly observations, throughout 24 hours, of the potential gradient were obtained during the period of 1915 to 1921, at times under very trying

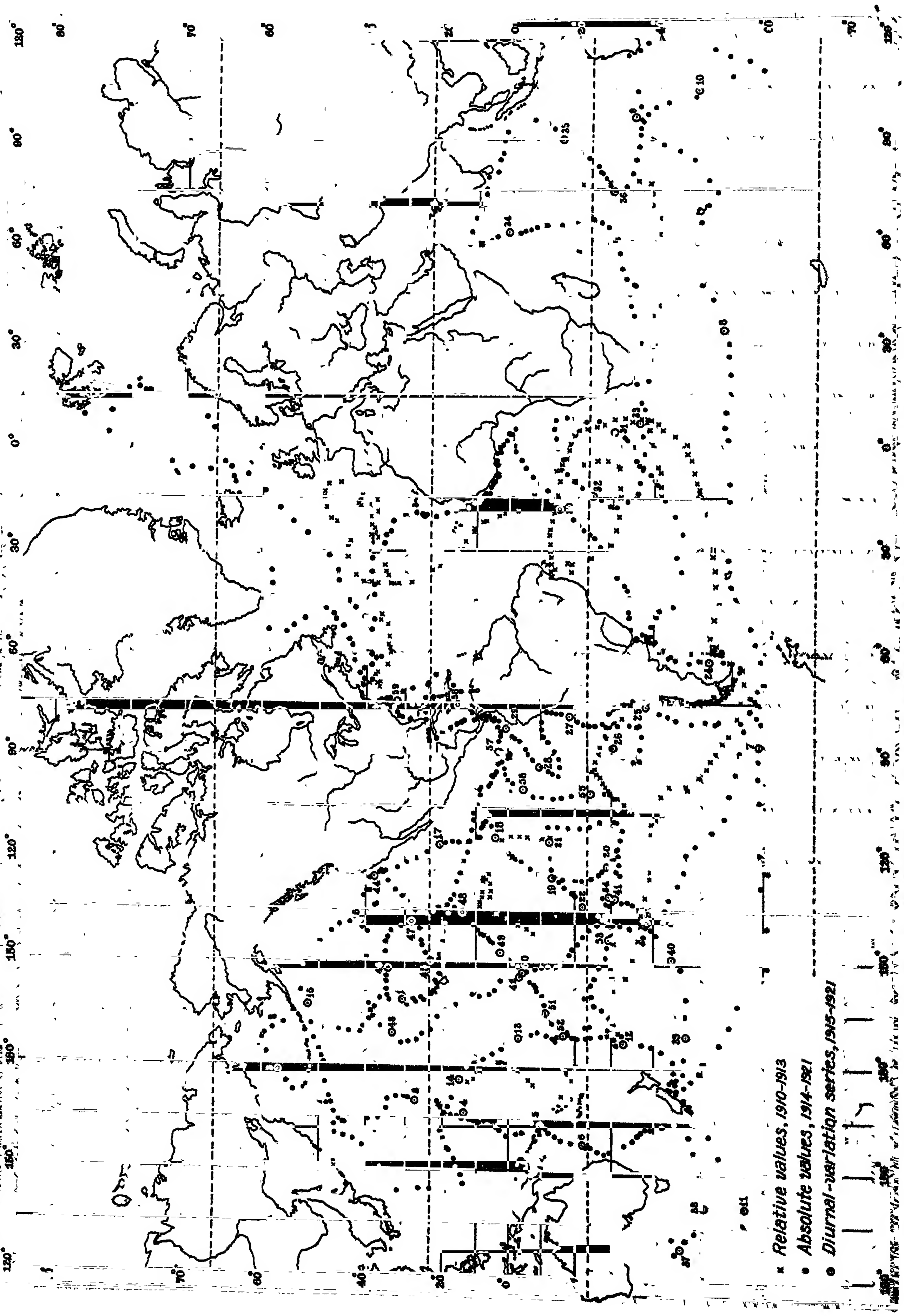

FIG. 51.—Distribution of Atmospheric Potential-Gradient Stations of the Carnegie, 1910-1921.

TABLE 65.—*Data Regarding Atmospheric-Electric Results Obtained on the Carnegie, 1915-1921, During Diurnal-Variation Observations.*

No.	Date (Greenwich)	T	Lat.	Long. E. of Gr.	P	S	D. V. D	Ocean	P_r
	1915		°	°	v/m		v/m		v/m
1	Jul 7– 8	1915.5	30.6 N	198.7	132	40	20	Pacific..............	122
2	Aug 13–15	.6	57.0 N	178.2	136	41	24	Do..............	126
3	Sep 3– 4	.7	27.3 N	169.8	128	66	26	Do..............	111
4	Sep 16–17	.7	13.8 N	166.3	112	24	21	Do..............	107
5	Oct 9–10	.8	9.8 S	162.7	127	38	28	Do..............	119
6	Oct 16–17	.8	21.9 S	157.2	134	81	18	Do..............	113
7	Dec 30–31	1916.0	59.0 S	272.8	127	65	20	Do..............	112
	1916								
8	Jan 28–29	1916.1	53.1 S	33.8	191	42	28	Indian..............	183
9	Feb 16–17	.1	34.5 S	96.0	164	38	16	Do..............	157
10	Feb 25–26	.2	48.2 S	104.1	187	24	20	Do..............	185
11	Mar 20–21	.2	57.0 S	140.0	163	42	46	Do..............	155
12	May 26–27	.4	32.6 S	187.0	144	131	22	Pacific..............	112
13	Jun 23–24	.5	2.9 S	187.6	126	172	15	Do..............	81
14	Jul 2– 3	.5	15.1 N	176.2	142	58	13	Do..............	131
15	Sep 4– 5	.7	52.1 N	197.0	115	31	27	Do..............	113
16	Sep 14–15	.7	40.9 N	221.8	132	80	23	Do..............	116
17	Nov 9–10	.9	20.7 N	243.4	174	88	28	Do..............	156
18	Nov 29–30	.9	3.4 N	246.0	135	60	28	Do..............	126
19	Dec 7– 8	.9	13.7 S	234.4	152	86	22	Do..............	135
20	Dec 15–16	1917.0	28.2 S	237.8	108	19	24	Do..............	111
	1917								
21	Jan 8– 9	1917.0	12.5 S	244.9	105	90	9	Do..............	87
22	Jan 18–19	.1	22.2 S	226.3	140	60	17	Do..............	132
23	Jan 30–31	.1	38.5 S	222.0	169	71	30	Do..............	158
24	Feb 20–21	.1	51.6 S	297.1	212	54	37	Atlantic..............	205
	1918								
25	Jan 9–10	1918.0	38.5 S	284.3	180	69	36	Pacific..............	173
26	Jan 31–32	.1	30.3 S	272.4	145	86	16	Do..............	134
27	Feb 17–18	.1	19.2 S	281.0	233	112	51	Do..............	214
28	Apr 10–11	.3	10.0 S	266.4	120	82	16	Do..............	111
29	Apr 18–19	.3	0.7 N	277.5	154	60	15	Do..............	152
	1919								
30	Dec 30–31	1920.0	15.8 S	341.8	128	28	18	Atlantic..............	143
	1920								
31	Mar 16–17	1920.2	30.4 S	3.8	98	67	15	Do..............	103
32	Apr 8– 9	.3	24.6 S	345.7	88	8	17	Do..............	110
33	Apr 19–20	.3	36.4 S	6.4	81	14	10	Do..............	102
34	Jun 17–18	.5	0.5 N	62.8	99	24	16	Indian..............	118
35	Aug 9–10	.6	15.2 S	90.0	112	8	8	Do..............	136
36	Aug 18–19	.6	29.8 S	74.6	79	21	12	Do..............	99
37	Oct 8– 9	.8	45.2 S	128.1	105	47	20	Do..............	119
38	Oct 11–12	.8	50.1 S	140.2	130	69	47	Do..............	137
39	Nov 23–24	.9	46.4 S	188.6	151	20	18	Pacific..............	173
40	Nov 29–30	.9	43.8 S	210.8	83	34	9	Do..............	101
41	Dec 9–10	.9	30.8 S	228.4	89	14	21	Do..............	113
	1921								
42	Jan 10–11	1921.0	8.0 S	205.6	91	38	9	Do..............	110
43	Jan 29–30	.1	32.7 N	188.9	94	10	12	Do..............	120
44	Feb 18–19	.1	38.0 N	234.4	119	32	28	Do..............	139
45	Apr 9–10	.3	28.0 N	210.0	66	22	8	Do..............	90
46	May 9–10	.3	33.6 N	207.8	109	32	12	Do..............	130
47	May 16–17	.4	28.0 N	221.8	89	34	10	Do..............	110
48	May 23–24	.4	18.9 N	224.2	93	10	9	Do..............	120
49	Jun 2– 3	.4	2.2 N	212.6	111	25	9	Do..............	134
50	Jun 7– 8	.4	4.0 S	206.9	109	50	17	Do..............	125
51	Jun 17–18	.5	11.8 S	195.5	98	8	14	Do..............	116
52	Jul 29–30	.6	17.0 S	188.2	123	38	12	Do..............	143
53	Aug 23–24	.6	29.0 S	216.6	91	27	10	Do..............	114
54	Aug 30–31	.7	29.4 S	228.9	98	26	15	Do..............	122
55	Sep 14–15	.7	24.5 S	258.4	97	29	8	Do..............	120
56	Sep 21–22	.7	4.7 S	260.2	102	26	12	Do..............	126
57	Sep 28–29	.8	2.4 N	271.0	53	17	11	Do..............	80
58	Oct 23–24	.8	15.3 N	284.5	121	52	22	Atlantic..............	138
59	Nov 1– 2	.8	32.0 N	285.3	117	10	18	Do..............	146

conditions, as I myself witnessed on the homeward journey of the *Carnegie* from Panama to Washington, October–November, 1921. The geographic locations of the stations where these diurnal-variation series were obtained are shown in Figure 21; it will be observed that the distribution of the stations in the Pacific Ocean is especially satisfactory, and we hope that on future cruises it will be found possible to obtain an equally satisfactory distribution in the Atlantic Ocean. With the aid of the station numbers, also given in Figure 21, the reader will be able to follow the grouping adopted.

Table 65 contains the data for the diurnal-variation observations, showing number, Greenwich dates, year and decimal thereof, latitude, longitude (east of Greenwich), daily mean value of the potential gradient P, the corresponding Wolfer sunspot number S, the average departure D of the diurnal-variation series, and the ocean in which the station is located. A column, P_r, has also been added which contains the values of P referred to the mean epoch 1918.5 and to the mean sunspot number 55 with the aid of the values of s and t given in Table 64; these reduced values range from 80 v/m (No. 57) to 214 v/m (No. 27), the average value for the 59 stations being 128 v/m. A good measure of the accuracy of the diurnal-variation observations is furnished by the D-quantity (the average difference, regardless of sign, of the observed values of P from the mean of day); the average value of D is 19 v/m. Except in a few instances, when observing conditions were doubtless unfavorable, the sea value of D, *obtained from one day's observations*, compares very favorably with those derived from certain fixed observatories with self-registering instruments.

An examination, which will be explained later, showed that, within the observational error, we may assume as a first approximation that practically the same type of annual variation of the potential gradient prevailed over the regions covered by the stations. Furthermore, in order to study successfully any possible relationship between sunspottedness and some measure of the diurnal variation of P, groups A, B, C, D, and E were formed, each containing stations distributed throughout an entire year. To accomplish this it was necessary to use at times the same station more than once, and stations 25 to 29, being isolated ones, could not be used at all.

TABLE 66.—*Diurnal Variation of Potential Gradient, According to Greenwich Mean Time, as Derived from 59 Series Observed on the Carnegie, 1915-1921, Arranged into Groups to Eliminate Annual Variation and to Show Variability with Sunspottedness.*

Group..	*A*	*B*	*C*	*D*	*E*	*F*	Group..	*A*	*B*	*C*	*D*	*E*	*F*
Series...	1-13	8-20	11-24	30-41	42-59	1-59	Series..	1-13	8-20	11-24	30-41	42-59	1-59
T......	1916.0	1916.5	1916.8	1920.6	1921.5	1918.9	*T*......	1916.0	1916.5	1916.8	1920.6	1921.5	1918.9
S......	61.8	67.0	74.4	27.8	26.7	46.5	*S*......	61.8	67.0	74.4	27.8	26.7	46.5
h	*v/m*	*v/m*	*v/m*	*v/m*	*v/m*	*v/m*	*h*	*v/m*	*v/m*	*v/m*	*v/m*	*v/m*	*v/m*
1	−13	−19	−19	−12	− 8	−13	13	+ 4	+ 8	+ 7	+ 1	− 3	+ 6
2	−17	*−25*	*−23*	−16	−10	−16	14	+10	+ 8	+10	+ 3	+ 2	+ 7
3	−16	−20	−19	−17	−12	−16	15	+14	+21	+24	+ 8	+ 7	+10
4	−19	−21	−18	*−18*	−11	*−17*	16	+22	+18	+21	+ 8	+ 8	+15
5	*−19*	−18	−13	−12	*−14*	−15	17	+10	+ 6	+11	+20	+11	+18
6	−18	−20	−16	−14	−12	−14	18	+19	+15	+22	+29	+12	+20
7	−11	−16	−18	− 6	− 8	−13	19	+18	+27	+29	+34	+16	+24
8	− 6	− 9	−11	− 7	− 6	− 9	20	+15	+22	+27	+22	+20	+21
9	−11	− 9	−10	−14	− 6	−10	21	+16	+21	+17	+10	+14	+14
10	−12	− 5	−12	−12	− 3	− 9	22	+23	+18	+10	+ 8	+ 7	+10
11	−11	− 6	−10	− 9	− 2	− 7	23	+13	+ 7	0	+ 3	+ 1	+ 1
12	− 5	+ 2	+ 2	− 3	− 2	+ 1	24	− 4	− 8	−14	− 7	− 3	− 7

	A	*B*	*C*	*D*	*E*	*F*
Average value of *D* for day..................................	23.4	24.0	24.4	17.6	12.8	12.0
Average value of *P* for day..................................	144	149	144	93	99	124
Average latitude of group..................................	15° S	11° S	9° S	31° S	5° N	10° S
Average longitude of group..................................	158 E	177 E	219 E	152 E	228 E	202 E

Table 66 contains the diurnal variations of P for the 5 groups A to E, as also for F, the mean of the 59 series, all according to Greenwich mean time. The second row shows which series of Table 65 were utilized in the individual groups, the third row, the mean date T for the series, and the fourth row, the mean sunspot number, S. At the bottom of the table we have first the average departure D; for example, 23.4 is the average for series 1 to 13 of the daily values of D given in Table 65. Similarly, the quantities P, the average latitude, and the average longitude were derived.

It will be seen from Table 66 that the minimum diurnal-variation values (those italicized) and the maximum ones (those in bold-faced type) occur, on the average, within one hour of each other for all the groups, though the stations utilized range widely in longitude. For Group F (the entire series), the minimum is shown at about 4^h G. M. T. and the maximum at about 19^h or 7^h p. m., G. M. T. The fact that the diurnal variation of the potential gradient progresses chiefly according to universal time was first noted by Doctor Mauchly, while studying the *Carnegie* observations; for fuller information the interested reader may be referred to his report, pages 388 to 402.

The Fourier coefficients for the various groups, as computed by Mr. Duvall, will be found in Table 67. The values for Group F (59 series) are practically the same as those given in the bottom row of Table 80 of Doctor Mauchly's report (page 397).

TABLE 67.—*Results of Fourier Analysis of Diurnal Variation (d) of Potential Gradient (P), Observed on the Carnegie for Whole Years, 1915-1921.*

FORMULAE

$d = a_1 \cos\theta + b_1 \sin\theta + a_2 \cos 2\theta + b_2 \sin 2\theta + \ldots = c_1 \sin(\theta+\phi_1) + c_2 \sin(2\theta+\phi_2) + \ldots$ θ is counted from 0^h, midnight, G. M. T., at the rate of 15° per hour.

$c_r = \sqrt{c_1^2 + c_2^2 + c_3^2 + c_4^2}$

Group	A	B	C	D	E	F
Nos	1-13	8-20	11-24	30-41	42-59	1-59
T_m	1916.0	1916.5	1916.8	1920.6	1921.5	1918.9
S_m	61.8	67.0	74.4	27.8	26.7	46.5
	v/m	v/m	v/m	v/m	v/m	v/m
c_1	19.1	21.0	21.9	18.4	12.6	17.9
c_2	3.8	5.8	5.7	7.9	4.6	4.5
c_3	5.0	4.6	4.3	1.1	0.8	2.2
c_4	1.6	2.7	2.4	3.6	1.3	1.2
c_r	20.1	22.4	23.2	20.4	13.5	18.6
P_m	144	149	144	93	99	124
	°	°	°	°	°	°
ϕ_1	179	189	190	180	183	186
ϕ_2	204	193	244	240	209	227
ϕ_3	152	199	217	282	290	229
ϕ_4	252	265	293	51	289	352

Table 68 contains the measures D, c_1, and c_r, utilized to investigate a possible relationship with sunspottedness for the period of the *Carnegie* diurnal-variation series, July 7, 1915, to November 2, 1921. It will be observed from the column S (mean sunspot number for series) that while the observations do not extend over a complete sunspot cycle, they include about two years of the increasing portion of the cycle and about four years of the decreasing portion. An examination of the three sets of measures for the diurnal variation shows that they not only follow practically the same course from period to period, but also that the course of each is practically identical with that of the values of the potential gradient, as given in the P column. The latter fact is in agreement with that generally found at a number of fixed observatories during the past seven sunspot cycles.[a]

The formulæ used for the investigation are (1), as given on page 364, and the reduced one (2), obtained by omitting the t-term; the resulting values of s, t, r_s, s' and r'_s,

[a] *Terr. Mag.*, vol. 29 (1924), p. 186, conclusion *d*.

will be found in Table 69. *It will be seen that the correlation coefficient for relationship between sunspottedness and measure of the diurnal variation of the potential gradient is, on the average, about 0.7, and that increasing amplitude of the diurnal variation corresponds with increased sunspottedness; the amplitude is increased about 0.1 v/m for an increase in the sunspot number of 1.* This is in excellent agreement with the result obtained from the diurnal-variation observations of P at the Ebro Observatory, Spain, where the average value of P approaches closest to that of the ocean observations (see No. 1, Table 59, page 370). As the result of the combined effect of the variations s and t, the *computed* decrease in the amplitude c_1, of the 24-hour wave of the diurnal variation between the average times and sunspottedness of groups C and E would be 6.4 v/m, the observed decrease being 9.3 v/m.

TABLE 68.—*Quantities Derived from 59 Potential-Gradient Series Observed on the Carnegie, 1915-1921, Used in Investigating Relationship with Sunspottedness.*

Group	No. of series	Period	Average T	Average S	Average P	Diur. var. of P: D	Diur. var. of P: c_1	Diur. var. of P: c_r	Ocean
					v/m	v/m	v/m	v/m	
A	1–13	1915, Jul. 7 to 1916, Jun. 24.....	1916.0	61.8	144	23.4	19.1	20.1	Pacific, Indian
B	8–20	1916, Jan. 28 to 1916, Dec. 16....	1916.5	67.0	149	24.0	21.0	22.4	Indian, Pacific
C	11–24	1916, Mar. 20 to 1917, Feb. 21...	1916.8	74.4	144	24.4	21.9	23.2	Indian, Pacific, Atlantic
D	30–41	1919, Dec. 30 to 1920, Dec. 10...	1920.6	27.8	93	17.6	18.4	20.4	Atlantic, Indian, Pacific
E	42–59	1921, Jan. 10 to 1921, Nov. 2....	1921.5	26.7	99	12.8	12.6	13.5	Pacific, Atlantic
	Mean	....	1918.3	51.5	126	20.4	18.6	19.9	

TABLE 69.—*Relation Between Sunspottedness and Diurnal Variation of Potential Gradient.*

Quantity	s		t		r_s	s'		r'_s
v/m	v/m	p. ct.	v/m	p. ct.		v/m	p. ct.	
$D_m=20.4$	+0.07	+0.33	−1.34	−6.57	0.77	+0.21	+1.03	0.94
$c_1=18.6$	+0.10	+0.51	−0.35	−1.86	0.73	+0.13	+0.71	0.82
$c_r=19.9$	+0.09	+0.45	−0.36	−1.81	0.61	+0.13	+0.65	0.76
Mean	....	+0.43	....	−3.41	0.71	....	+0.80	0.84

REGARDING SECULAR VARIATION OF ATMOSPHERIC POTENTIAL-GRADIENT.

It will be of some interest to compare, for stations having about the same value of P, the values derived in this report of t, the more or less progressive change per year, which may be superimposed on the sunspot variation of the potential gradient and of its variations. The periodicity of t, in the absence of sufficiently long series of observa-

TABLE 70.—*Comparison of Values of t Derived from Observations at the Ebro Observatory and on the Carnegie.*

No.	Period	Observations	Quantity	t	Source
				p. ct.	
1	1913–1922; all months..............	At Ebro Observatory........	P	−2.79	Table 47
2	1913–1922; summer months.........	Do.....................	P	−2.32	Table 49
3	1913–1922; winter months...........	Do.....................	P	−4.55	Table 50
4	1913–1922; all months..............	Do.....................	D. V.	−2.74	Tables 58 and 60
5	1915–1921; all observations..........	On the *Carnegie*.............	P	−3.75	Table 64
6	1915–1921; 59 D. V. series..........	Do.....................	P	−4.06	Below Table 64
7	1915–1921; all months..............	Do.....................	D. V.	−3.41	Table 69
	Mean..			−3.37	

tions, can not at present be determined, though there are indications that its magnitude and sign may depend on the state of solar activity during any particular cycle.

It will be observed that all the values of t are negative and of about the same magnitude, whether derived from the observations of the potential gradient and of its diurnal variation at the Ebro Observatory, Spain, or aboard the Carnegie.

SUNSPOTTEDNESS, CONDUCTIVITY, AND AIR-EARTH CURRENTS.

Values of the *conductivity* λ, of the atmosphere, both for positive and negative electricity, have been obtained by the Gockel-Schering method almost daily from eye-readings, about 10^h45^m to 11^h15^m, at the Ebro Observatory, Spain, since 1914. The mean annual values of λ for the period 1914–1923, whether deduced from the electrically quiet days, or all days, show an increase with increasing sunspottedness; the value of s is +0.26 per cent of the mean value of λ and the correlation coefficient nearly 0.7.[a]

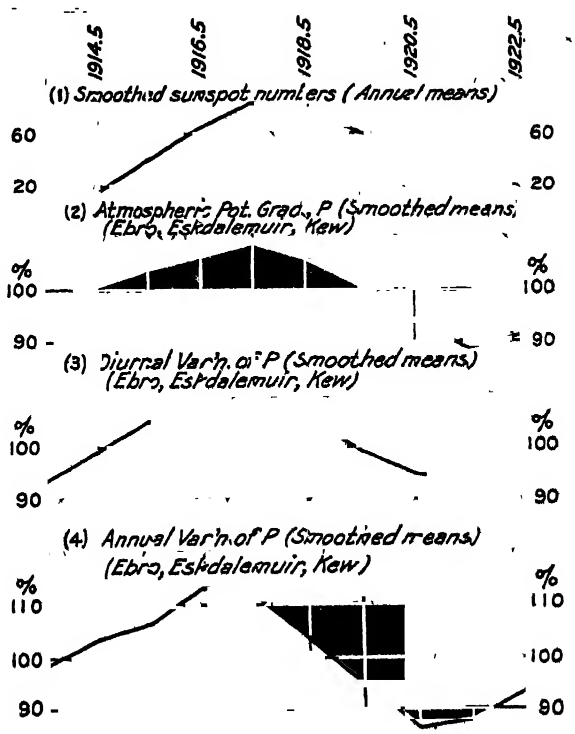

FIG. 22.—Variation of Atmospheric Potential-Gradient during Solar Cycle, 1913–1922.

The continuous registrations of the negative electric conductivity at the Potsdam Observatory, Germany, on the other hand, during the past cycle show but little, if any, fluctuation in consonance with sunspottedness. However, according to information received from the observatory, annoying disturbances in the conductivity observations occur much more frequently than those in the potential gradient, because of the continual effect from cobwebs in the observation space, 20 meters long. Unfortunately, the series of conductivity observations at other observatories as well as the diurnal-variation series thus far obtained on the *Carnegie* are not yet sufficiently extensive to permit of utilization here. *Accordingly, whether the electric conductivity of the atmosphere varies with solar activity is a question the definite settlement of which must be reserved for the future.*

It does not necessarily follow that if the potential gradient P varies with sunspottedness, so should also the electric conductivity λ, as measured near the Earth's surface. P

[a] *Terr. Mag.*, vol. 29 (1924), pp. 173–174.

at the Earth's surface may vary as the result of induction effects from charges in the highest regions of the atmosphere, but unless some radiation of a more highly penetrating character than any we know of at present gets through the atmosphere and affects layers of air close to the Earth's surface, it is difficult to see how λ should be influenced by varying solar activity.

From the combined observations of *air-earth current* at the Ebro Observatory and at the Kew Observatory, during the past cycle, it would appear that the strength of the current increases with increasing sunspottedness; s is about +0.32 per cent of the average current strength and the correlation coefficient is about 0.6.[a]

The air-earth current-density results obtained from the *Carnegie* observations give about the same indications as those for Ebro and Kew.

General Conclusions Regarding Sunspottedness and Atmospheric Potential-Gradient for 1913–1922.

The data presented in Table 71 are the smoothed, or $\frac{1}{4}(a+2b+c)$ means, in order to minimize the effect of local disturbing influences. Thus the values for P, d (diurnal variation), and a (annual variation) for 1913, are the derived ones from the 3 years 1912 to 1914 of observations at Ebro, Eskdalemuir, and Kew; etc. Similarly the sunspot numbers, S, were obtained; they depend on final sunspot numbers as derived by Professor Wolfer, who kindly furnished us in advance of usual publication the final numbers for 1923 and 1924. *As good a correspondence between sunspot curve (No. 1) and the three atmospheric-electric curves (Nos. 2, 3, and 4) is shown in Figure 22 for the cycle 1913–1922, as in general is found to be the case between sunspottedness and some measure of terrestrial magnetic activity.* Curve No. 4, because of the difficulty of determining accurately the annual variation from single years of observation, is necessarily less certain.

TABLE 71.—*Data Used for Figure 22.*

Year	S	Potential Gradient P	Average departure D. V., d	Average departure A. V., a
	(1)	(2)	(3)	(4)
		p. ct.	*p. ct.*	*p. ct.*
1913.......	4.0	98	93	99
1914.......	17.0	101	99	104
1915.......	40.4	104	105	107
1916.......	66.4	107	104	114
1917.......	86.4	109	106	112
1918.......	82.2	106	106	103
1919.......	61.4	101	99	95
1920.......	41.2	94	95	86
1921.......	26.0	88	94	87
1922.......	15.1	91	97	94
Mean..	44.0	100	100	100

Let us next form in the same manner as for Table 71 the smoothed means of the annual P' values, as given in the last three columns of Table 47 for the observatories at Ebro, Eskdalemuir, and Kew, using only the period for which there are corresponding ocean values of the potential gradient (Table 63). Correcting the *Carnegie* values for drift (the t-term, Table 64) and reducing them to the same sunspot numbers as for the observatory values with the aid of the quantity s (Table 64), smoothed means of the ocean values are obtained. The corresponding observatory and ocean values of the potential gradient thus derived, expressed in percentages of their respective mean values for the period 1916 to 1920, are as follows:

[a] *Terr. Mag.*, vol. 29 (1924), pp. 173-174.

Year	Sunspot number	Potential Gradient (Ebro, Eskdalemuir, Kew)	Potential Gradient (*Carnegie*)
		p. ct.	*p. ct.*
1916	66	100	100
1917	86	104	103
1918	82	103	103
1919	61	99	101
1920	41	95	93

It will be seen that for the same period the annual march of the potential gradient was practically the same at the three observatories in western Europe and on the oceans.

Table 72 summarizes the values of the sunspot coefficient *s*, and of the correlation coefficient *r*, derived from the observations at the Ebro Observatory during the past sunspot cycle, 1913–1922, and on the *Carnegie*, 1915–1921. The comparison of the *Carnegie* results is made with those from the Ebro Observatory, for the reason, as already stated elsewhere, that the average value of the potential gradient, 109 v/m, at this observatory differs not greatly from the average value, about 130 v/m, of all the ocean observations. It will be seen that the *Carnegie* values compare favorably with those at a fixed observatory.

TABLE 72.—*Summary of Values of s and r Derived from Observations at the Ebro Observatory and on the Carnegie.*

No.	Period	Observations	Quantity	*s*	*r*	Source
				p. ct.		
1	1913–1922; all months	At Ebro Observatory	*P*	+0.35	0.92	No. 1, Table 48
2	1913–1917; all months	Do	*P*	+0.29	0.96	No. 6, Table 48
3	1918–1922; all months	Do	*P*	+0.48	0.93	No. 11, Table 48
4	1913–1922; all months	Do	*D. V.*	+0.38	0.77	No. 1, Table 59
5	1913–1917; all months	Do	*D. V.*	+0.33	0.93	No. 6, Table 59
6	1918–1922; all months	Do	*D. V.*	+0.50	0.69	No. 11, Table 59
7	1915–1921; all observations	On the *Carnegie*	*P*	+0.22	0.70	Table 64
8	1915–1921; 59 D. V. series	Do	*P*	+0.50	0.77	Below Table 64
9	1915–1921; 59 D. V. series	Do	*D. V.*	+0.43	0.71	Table 69

The present measures of solar activity—sunspots (frequency and area), prominences, faculæ, umbræ, flocculi, solar-constant values, etc.—have not yet been found wholly satisfactory in studies as to strict synchronism between solar activity and the Earth's magnetic and electric activity, even if annual mean values are used. These solar measures, besides not distinguishing, at present, between electrically or magnetically active and inactive sunspot areas, do not give us a clue as to the preponderance in the sign of the electrically-charged particles which may enter the upper regions of our atmosphere during solar outbursts. Possibly continued study of correlations between solar activity and the phenomena of atmospheric electricity may some day shed light on this important question and ultimately lead to the establishment of a satisfactory theory to account for the origin and maintenance of the Earth's electric charge.

Chief assistance in the computational work has been received from Messrs. W. J. Peters, C. R. Duvall, and C. C. Ennis, and it is a pleasure to make record of their very effective aid in these investigations.

The general conclusion from the investigations based on land and ocean results and described in the preceding pages is to indicate with a high degree of probability that during the cycle of 1913–1922 the atmospheric potential-gradient increased with increasing sunspottedness by at least 20 per cent of its mean value for the cycle between the years of minimum and maximum sunspottedness. The same statement applies with regard to measures of the diurnal variation and of the annual variation of the potential gradient. At an undisturbed locality, where the value of the potential gradient approximates to the average ocean value of about 130 v/m, the effect of sunspottedness may be found greater than the amount stated.

ANNUAL VARIATION OF ATMOSPHERIC POTENTIAL-GRADIENT.

LAND OBSERVATIONS.

As the result of a study of every available series of observations of the atmospheric potential-gradient, made during the past four decades, from the Arctic to the Antarctic regions, the following general types of the annual variation at *land stations* for "fine weather," or electrically-undisturbed days, may be distinguished:

Type a.—At numerous stations in the Northern Hemisphere, including high-latitude stations, the tendency is for the potential gradient to have a maximum value near December and a minimum value near June. This same general type was disclosed from a year's observations, 1911–1912, by Doctor G. C. Simpson at a high-latitude station in the Southern Hemisphere, namely, Cape Evans in latitude 77°.6 south and longitude 166°.4 east. The available Antarctic observations, if days of negative potential are excluded, are in general accord with Doctor Simpson's observations at Cape Evans. At the Watheroo Magnetic Observatory, Western Australia, in latitude 30°.2 south and longitude 115°.9 east, one year's observations, made under the direction of Messrs. G. R. Wait and H. F. Johnston in 1924, show a maximum value of the potential gradient in February and a minimum in July, hence an annual variation approximating to type *a*. The only exception to type *a* thus far found for a station in the Northern Hemisphere is Helwan, Egypt, mentioned under type *b*.

Type b.—At Helwan, Egypt (latitude 29°.9 north, longitude 31°.3 east), 8 years of observations, 1907–1914, consistently showed a minimum potential-gradient about December and a maximum about July, hence, the reverse of type *a*. Type *b* was also shown by the observations, from 1858 to 1862, at the Flagstaff Observatory, Melbourne, Australia, in latitude 37°.8 south and longitude 144°.8 east, and by Doctor G. Berndt's observations at Buenos Aires, Argentina, 1911–1912, in latitude 34°.5 south and longitude 58°.6 west. Some observations, 1906–1908, made by Doctor G. Angenheister at the Apia Observatory, in Western Samoa, likewise gave an annual variation of general type *b*; however, in this early series days of negative potential were not excluded. His later observations, 1914–1918, dependent upon undisturbed days, showed an annual variation of type *c*, which has been confirmed by Mr. Andrew Thomson's observations, 1922–1924, made under the joint auspices of the New Zealand Government and of the Department of Terrestrial Magnetism of the Carnegie Institution of Washington.

Type c.—At certain low-latitude stations in the Southern Hemisphere, as for example, Batavia in latitude 6°.2 south and longitude 106°.8 east, Apia in latitude 13°.8 south and longitude 171°.8 west, and Rio de Janeiro in latitude 22°.4 south and longitude 43°.6 west, a mixture of types *a* and *b* is found, resulting in two chief maximum and two chief minimum values of the potential gradient during the year. At the magnetic observatory of the Carnegie Institution of Washington, situated at Huancayo, Peru, in latitude 12°.0 south and longitude 75°.3 west, and at an elevation of about 11,000 feet, one year's observations, under Mr. W. C. Parkinson's direction, from March 1924 to February 1925, according to the reductions by Messrs. J. A. Fleming and C. C. Ennis, show an average maximum value of the potential gradient during the period October to March of 42.2 v/m, and an average minimum value during the period April to September of 35.9 v/m.

For most stations, in both the Northern and Southern Hemispheres, the mean value of the potential gradient for the six months October to March, when the Earth is nearest to the Sun, is greater than the mean value for the six months April to September, when the Earth is farthest from the Sun. The two outstanding exceptions from this general rule, if we confine our attention to series since 1900, are the observations at Helwan and Buenos Aires, cited under type *b*. The results at Helwan depend on all days on which complete electrograph records with no negative potential were obtained. No tabulation of results for only electrically-quiet days appears to have been made. The results at Buenos Aires are dependent on electrometer readings made three times daily for one year from May 1911 to April 1912; the observations on the days characterized as "normal" and without negative potential show a maximum value of P in July and a minimum value in February. It would be highly desirable to obtain additional observations at these stations, and that the annual variation be derived both on the basis of electrically undisturbed and disturbed days.

On the average, from the Arctic to the Antarctic, the potential gradient varies from minimum to maximum value about 60 per cent of its mean annual value. The more numerous data in the Northern Hemisphere would indicate that the range of the annual

variation decreases with decreasing latitude, though further evidence is required before a definite statement may be made.

OCEAN OBSERVATIONS.

In order to ascertain whether the values of the potential gradient observed on the *Carnegie* exhibit an annual variation, and what type, the 59 series enumerated in Table 65 were utilized. The values of P, given in the sixth column of that table, are the mean values of the day as obtained from the observations for diurnal variation; hence no reduction to mean of day is required. However, it is necessary to correct these observed values because of the sunspot variation, s, and the long-time variation, t. Accordingly, the P values were reduced to the mean epoch 1918.5 and to the mean sunspot number 55 with the aid of the values of s and t in Table 64; these reduced values are designated P_r and are entered in the last column of Table 65.

TABLE 73.—*Annual Variation of Potential Gradient, Derived from 59 Diurnal-Variation Series Obtained on the Carnegie 1915-1921, and Arranged According to Zones.*

Designation	Number of series	Average: Decimal of year	Average: Lat.	Average: Long. E. of Gr.	Average: P_r	Ocean
	Zone *A* (Stations North of 30° N)					
			°	°	v/m	
a	43, 44	0.1	35 N	212	120	Pacific
b	46	0.3	34 N	208	116	Do.
c	1	0.5	31 N	199	122	Do.
d	2	0.6	57 N	178	126	Do.
e	15, 16	0.7	46 N	209	114	Do.
f	59	0.8	32 N	285	146	Atlantic
	Mean of all (year)	0.5	39 N	215	124	
	Mean of *f*, *a*, *b* (Nov.–May)	0.0	34 N	235	127	
	Mean of *c*, *d*, *e* (Jul.–Sep.)	0.6	45 N	195	121	
	Zone *B* (Stations South of 30° S)					
a	7, 25	0.0	49 S	279	142	Pacific
b	8, 9, 23	0.1	42 S	117	166	Indian and Pacific
c	10, 11, 31	0.2	45 S	83	148	Indian and Atlantic
d	33	0.3	36 S	6	102	Atlantic
e	12	0.4	33 S	187	114	Pacific
f	37, 38	0.8	48 S	134	128	Indian
g	39, 40, 41	0.9	40 S	209	129	Pacific
	Mean of all (year)	0.4	42 S	145	133	
	Mean of *g*, *a*, *b* (Nov.–Jan.)	0.0	44 S	202	146	
	Mean of *c*, *d*, *e*, *f* (Feb.–Oct.)	0.4	40 S	102	123	
	Zone *C* (Stations 30° N to 30° S)					
a	20, 21, 30, 42	0.0	15 S	258	113	Pacific and Atlantic
b	22, 26, 27	0.1	24 S	260	160	Pacific
c	28, 29, 32, 45	0.3	3 S	275	116	Pacific and Atlantic
d	47, 48, 49, 50	0.4	10 N	216	122	Pacific
e	13, 14, 34, 51, 52	0.5	3 S	162	118	Indian and Pacific
f	35, 36, 53	0.6	25 S	127	116	Do.
g	3, 4, 54, 55, 56	0.7	3 S	217	117	Pacific
h	5, 6, 57, 58	0.8	4 S	219	112	Pacific and Atlantic
i	17, 18, 19	0.9	3 N	241	189	Pacific
	Mean of all (year)	0.5	7 S	219	124	
	Mean of *h*, *i*, *a*, *b* (Oct.–Feb.)	0.0	10 S	244	131	
	Mean of *c*, *d*, *e*, *f*, *g* (Apr.–Sep.)	0.5	5 S	199	118	

Next the values of P_r were assembled for three zones: *A* (stations north of 30° N), *B* (stations south of 30° S), and *C* (stations in the region from 30° N to 30° S). The results for different times (decimals) of year and for the three zones will be found in Table 73. It will be observed from the second and third rows below each zone that the mean potential gradient is greater for the period when the Earth is nearer to the Sun than for the period when the Earth is farther away from the Sun.

TABLE 74.—*Results from 59 Diurnal-Variation Series Obtained on the Carnegie, in All Oceans, 1915-1921, Showing Annual Variation of Potential Gradient.*

Designation	Number of series	Average: Decimal of year	Average: P_r	Ocean
			v/m	
a	7, 20, 21, 25, 30, 42	0.0	123	Pacific and Atlantic
b	8, 9, 22, 23, 24, 26, 27, 43, 44	0.1	150	Indian, Pacific, Atlantic
c	10, 11, 31	0.2	148	Indian and Atlantic
d	28, 29, 32, 33, 45, 46	0.3	113	Pacific and Atlantic
e	12, 47, 48, 49, 50	0.4	120	Pacific
f	1, 13, 14, 34, 51	0.5	119	Pacific and Indian
g	2, 35, 36, 52, 53	0.6	119	Do.
h	3, 4, 15, 16, 54, 55, 56	0.7	116	Pacific
i	5, 6, 37, 38, 57, 58, 59	0.8	121	Pacific, Indian, Atlantic
j	17, 18, 19, 39, 40, 41	0.9	134	Pacific
	Mean of all (year)		126	
	Mean of *i, j, a, b, c* (Oct.–Mar.)	0.0	135	
	Mean of *d, e, f, g, h* (Apr.–Sep.)	0.5	117	

It would seem from the foregoing facts that, as a first approximation, we may assume, within the observational error, that the annual variation of the potential gradient is of about the same general type over the various oceans. Hence in Table 74 will be found collected the mean values of P_r for different times of year, as derived from the entire 59 series. We conclude as follows:

In general over the oceans the atmospheric potential-gradient is, on the average, greater during the period October to March than during the period April to September, when the Earth is farthest away from the Sun.

Since a similar general conclusion was reached from the land observations, there is a possibility that the annual variation of the potential-gradient, like the diurnal variation, may have to be ascribed primarily to cosmic causes. It is hoped that opportunity will be afforded to obtain further evidence, both on land and at sea, on these matters destined to be of high importance in the theoretical interpretation of the phenomena of atmospheric electricity.

STUDIES IN ATMOSPHERIC ELECTRICITY BASED ON OBSERVATIONS MADE ON THE CARNEGIE, 1915 - 1921

By S. J. Mauchly

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STUDIES IN ATMOSPHERIC ELECTRICITY BASED ON OBSERVATIONS MADE ON THE CARNEGIE, 1915-1921.

By S. J. Mauchly.

INTRODUCTION.

In 1920, at the request of Doctor Louis A. Bauer, Director of the Department of Terrestrial Magnetism, the author undertook the analysis and study of the atmospheric-electric data accumulated on the fourth and fifth cruises of the *Carnegie*. At that time, owing to various causes brought on by the war, there had been no final determinations of the instrumental constants to be used for reducing to absolute values the results of the atmospheric-electric observations made aboard the vessel. It was thought, however, that a preliminary analysis of the data would be helpful in planning the work of the sixth cruise and would indicate at least the main features of any outstanding results. It later became possible to include also in the preliminary analysis the data obtained on the *Carnegie* during the first year of Cruise VI.

For the potential gradient of the atmosphere the results of the preliminary analysis were announced in 1921.[a] They indicated that, as a first approximation, the chief component of the diurnal variation of the potential gradient over the oceans is a "wave" of 24-hour period occurring simultaneously in the same phase in all localities. It was also pointed out that the diurnal variation observed over the oceans was decidedly similar to and in phase with that observed over land in polar latitudes and to that which prevails during the winter at many places in the north temperate zone.

On account of the importance of the above conclusion, it seemed desirable to make as early an examination as possible of the diurnal-variation data obtained during the last half of Cruise VI. Since diurnal variation involves relative values only, this examination, too, was made before the determination of the final instrumental constants had been completed. The results of this examination were found to confirm the conclusions of 1921 with regard to the general features of the diurnal variation of the potential gradient of the atmosphere over the oceans. The latter investigation was also extended to include all available data on the diurnal variation of the potential gradient at land stations. It was found, as in 1921, that there was good phase agreement on a universal-time basis between the diurnal variation as observed from practically all observations in high latitudes, both in the Arctic and Antarctic regions, and that found to obtain over the oceans. Further, it was found that the 24-hour Fourier wave at the great majority of land stations was in practical phase agreement on universal time with the prime daily wave over the oceans without regard to location. Thus there was established a strong probability that in general the 24-hour wave of the potential gradient progresses approximately according to universal time over the entire surface of the Earth.[b]

In the meantime, special standardizing observations, for the determination of the factors required for the reduction of volts observed with the potential-gradient apparatus on the *Carnegie* to volts per meter in the open had been made whenever practicable during Cruise VI. From the results of these and other special observations made after the conclusion of Cruise VI, it became possible to derive satisfactory reduction-factors for each set of sail positions under which the potential gradients were observed at sea. For

[a] Mauchly, S. J. Note on the diurnal variation of the atmospheric-electric potential-gradient, *Phys. Rev.*, n. s., vol. 18 (1921), pp. 161–162 and 477; also, Recent results derived from the diurnal-variation observations of the atmospheric-electric potential-gradient on board the *Carnegie*, *Bull. National Research Council* No. 17 (1922), pp. 73–77.

[b] Mauchly, S. J. On the diurnal variation of the potential gradient of atmospheric electricity, *Terr. Mag.*, vol. 28 (1923), pp. 61–81; and *Bull. National Research Council*, No. 41 (1924), pp. 131–135.

details, see "Atmospheric-Electric Results Obtained Aboard the *Carnegie*, 1915–1921," this volume, pages 195 to 286.[a]

Similarly, the determinations of the electrical capacities and other constants of the various atmospheric-electric instruments have made it possible to reduce to absolute values all data for each of the other elements under observation on the *Carnegie* during the years 1915 to 1921. Thus it becomes possible to investigate the magnitudes, distributions, and time-variations of the several elements over the entire period of the observations covering at least half of the surface of the globe.

The studies which follow are based on data given in the Table of Final Results, Volume V, pages 212 to 265, and therefore, so far as the *absolute* values of the elements are concerned, those here stated supersede those given in the preliminary publications to which reference has been made in footnotes *a* and *b*, page 387.

THE DIURNAL VARIATION OF THE ATMOSPHERIC POTENTIAL-GRADIENT WITH SPECIAL REFERENCE TO ITS UNIVERSAL-TIME COMPONENT.

EVIDENCE FROM SPECIAL 24-HOUR SERIES OF OBSERVATIONS.

All the potential-gradient observations on the *Carnegie* during cruises IV, V, and VI (1915–21) were made with the mechanical-electrode type of apparatus described by Swann in Volume III (pp. 380–383). For the diurnal-variation observations the general procedure was to make a set of 20 observations during each of 24 consecutive hours. A set of 20 observations requires about 20 minutes, and the mean value of the potential gradient derived from the set is referred to the mean time of the observations.

In order to secure mean diurnal-variation curves free from errors due to the large changes from day to day in the absolute value of the potential gradient, no series of observations was utilized unless it covered approximately an entire 24-hour period, and was complete or could be completed by justifiable interpolation. On this principle of selection it was necessary to reject many series which were terminated by the advent of unfavorable weather after having been continued throughout the greater part of a day, but it is believed that this loss was more than compensated by the fact that the data for each series utilized correspond to an actually occurring 24-hour sequence of the phenomenon under investigation. Moreover, the individual daily curves show, in general, a greater consistency than is usually found in land observations, and indicate the possibility of obtaining approximately correct mean curves from a smaller number of days than would normally be required for land observations.

TABLE 75.—*Dates and Geographical Coordinates of Ten 24-Hour Series of the Carnegie Potential-Gradient Observations.*

Group *A*			Group *B*			
Date	Lat.	Long.	Date	Lat.	Long.	Long. Diff. (*A–B*)
	°	°		°	°	°
Feb 20–21, 1917	51.6 S	297.1 E	Oct 8–9, 1920	45.2 S	128.1 E	169.0
Dec 30–31, 1919	15.8 S	341.8 E	Sep 16–17, 1915	13.8 N	166.3 E	175.5
Mar 16–17, 1920	30.4 S	3.8 E	Jun 23–24, 1916	2.9 S	187.6 E	176.2
Apr 8–9, 1920	24.6 S	345.7 E	Oct 9–10, 1915	9.8 S	162.7 E	183.0
Apr 19–20, 1920	36.4 S	6.4 E	May 26–27, 1916	32.6 S	187.0 E	179.4

Mean longitudes: Group *A* = 343° E.; Group *B* = 166° E. Mean longitude-difference = 177°.

If mean diurnal-variation curves for the three chief oceans are derived from these observations in the usual manner, that is, if the first point on the mean curve represents the mean as to time and gradient of all observations made between midnight and 1^h local

[a] In what follows this section of the present volume will be referred to as "Volume V"; Volume III of the Researches of the Department of Terrestrial Magnetism will be designated as "Volume III."

mean time (L. M. T.), and so on throughout the local day, the times of maximum (or minimum) are found to be markedly different for the several oceans. For example, in the mean local-time curve corresponding to observations in the Pacific Ocean the chief daily maximum of the potential gradient occurs between sunrise and noon, while in the Atlantic it occurs in the late afternoon or evening, and in the Indian not until after midnight.

However, if account is taken also of the differences between the respective means, for the several oceans, of the longitude positions in which the observations were made, these differences are found to correspond approximately to the observed differences in the local times at which the daily maximum occurs. While this suggested an approximately simultaneous occurrence of, say, maximum, for each of the three oceans and, therefore, the propriety of referring observations directly to Greenwich mean time (G. M. T.), it seemed desirable to make a detailed test of the possibilities and results of such a procedure before deciding upon its general adoption.

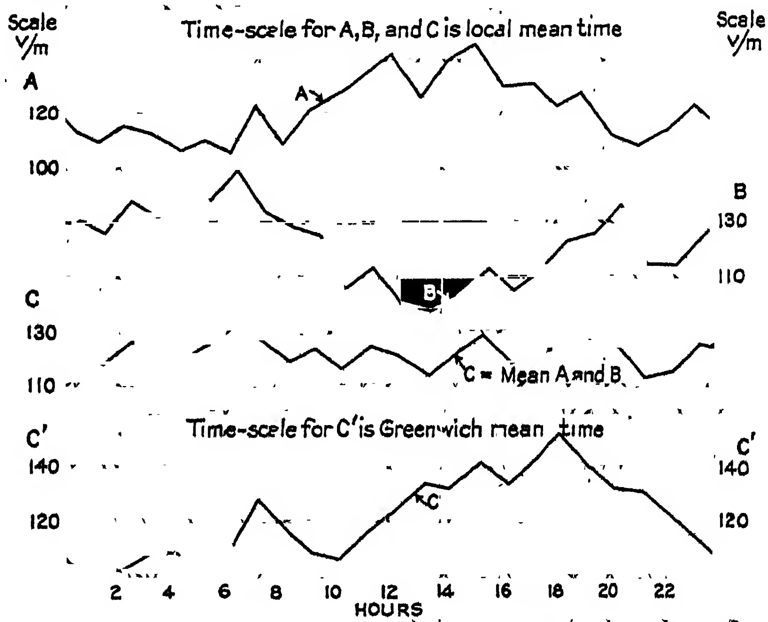

FIG. 23.—Comparison of Diurnal Variation of Potential Gradient at Ocean Stations with Longitude-Differences of 180° on L. M. T. and on G. M. T.

For a rigorous test of the point in question we should, of course, utilize only data from simultaneous observations at stations differing considerably in longitude. While such a direct comparison of *Carnegie* observations was obviously not practicable, nevertheless some very interesting results were obtained by comparing the observational data from five pairs of ocean diurnal-variation series, where the longitude-difference for each pair of stations was about 180°. The ten series were selected on the basis of their *longitude positions only* and with a view to their separation into two groups of five having relatively small longitude differences between the members of each group.

Table 75 gives the dates, geographical coordinates, and adopted groupings of these series, and Figure 23 the corresponding mean curves for each group separately, *A* and *B*, and for the two groups combined, *C*. It should be noted that for curves *A*, *B*, and *C*, each individual 20-minute set of observations was referred to local time, just as were the observations represented by the respective ocean-curves referred to above, and that curve *C*, therefore, represents the *local-time mean* of the ten series combined. The obvious phase difference of about 180° between curves *A* and *B* and the absence,

in curve *C*, of any well-defined periodic variation, indicates at once both a predominance, during the observations here represented, of an effect progressing approximately according to universal time and also the non-existence of any considerable local-time effects of world-wide occurrence. It will be seen later that no serious error is introduced here by the obvious inability to take account of the widely different times of year represented by the observations paired in Table 75 and Figure 23.

TABLE 76.—*Data on Basis of Greenwich Dates and Greenwich Mean Times for 59 Diurnal-*

No.	Ocean	Greenwich date	Lat.	Long. E. of Gr.	Greenwich mean times and observed values of atmospheric potential-gradient																			
					0h	P	1h	P	2h	P	3h	P	4h	P	5h	P	6h	P	7h	P	8h	P	9h	P
		1915	°	°	m	v/m	m	v/m	m	v/m	m	v/m	m	v/m	m	v/m	m	v/m	m	v/m	m	v/m	m	v/m
1	Pacific.......	Jul 8	30.6 N	198.7	[1]38	119	38	113	38	124	38	108	38	113	38	97	38	125	38	110	38	143	38	125
2	Pacific.......	Aug 13–14	57.0 N	178.2	56	158	56	151	56	160	56	147	56	152	56	149	56	133	56	141	56	124	56	87
3	Pacific.......	Sep 3– 4	27.3 N	169.8	27	151	27	198	27	100	27	93	27	89	27	92	27	94	27	120	27	119	27	112
4	Pacific.......	Sep 16–17	13.8 N	166.3	41	99	41	94	41	89	41	91	41	101	41	119	41	104	41	113	41	105	41	92
5	Pacific.......	Oct 9–10	9.8 S	162.7	45	115	45	108	45	104	45	119	45	106	45	68	45	87	45	115	45	113	45	141
6	Pacific.......	Oct 16–17	21.9 S	157.2	04	144	04	119	04	130	04	118	04	120	04	125	04	122	04	124	04	120	04	114
7	Pacific.......	Dec 30–31	59.0 S	272.8	43	87	43	104	43	108	43	95	43	100	43	138	43	115	43	124	43	124	43	135
		1916																						
8	Indian.......	Jan 28–29	53.1 S	33.8	56	167	56	166	56	162	56	139	56	154	56	149	56	151	56	156	63	213	56	182
9	Indian.......	Feb 16–17	34.5 S	96.0	33	134	33	103	[1]33	157	33	156	33	156	33	144	33	172	33	172	33	144	33	164
10	Indian.......	Feb 25–26	48.2 S	104.1	30	(176)	[1]35	175	22	(164)	09	151	10	166	10	174	10	169	15	208	10	182	10	202
11	Indian.......	Mar 19–20	57.0 S	140.0	40	144	40	117	40	139	40	122	40	115	40	94	40	100	40	117	40	94	40	124
12	Pacific.......	May 26–27	32.6 S	187.0	17	107	17	123	17	120	17	117	17	88	17	133	17	155	17	181	22	212	17	130
13	Pacific.......	Jun 23–24	2.9 S	187.6	18	117	18	105	18	108	18	148	18	145	18	130	18	129	18	120	18	125	18	124
14	Pacific.......	Jul 1– 2	15.1 N	176.2	42	131	42	111	42	119	42	124	42	134	42	127	42	131	42	147	42	143	42	163
15	Pacific.......	Sep 4– 5	52.1 N	197.0	40	84	40	99	40	130	40	144	40	131	40	112	40	102	40	102	40	94	40	105
16	Pacific.......	Sep 14–15	40.9 N	221.8	01	161	01	135	01	127	01	93	01	86	01	100	01	108	01	90	01	108	01	126
17	Pacific.......	Nov 9–10	20.7 N	243.4	22	182	22	135	22	123	22	131	22	134	22	167	22	126	22	153	22	157	22	147
18	Pacific.......	Nov 29–30	3.4 N	246.0	08	118	08	94	08	84	08	112	08	114	08	99	08	82	03	78	11	109	12	157
19	Pacific.......	Dec 7– 8	13.7 S	234.4	04	133	04	145	04	140	04	149	04	134	04	186	04	172	04	180	04	184	04	162
20	Pacific.......	Dec 15–16	28.2 S	237.8	54	130	54	89	54	80	54	86	54	73	54	80	54	76	54	81	54	85	54	94
		1917																						
21	Pacific.......	Jan 8– 9	12.5 S	244.9	30	93	30	79	30	103	30	98	30	115	30	104	30	103	30	97	30	108	30	112
22	Pacific.......	Jan 18–19	22.2 S	226.3	50	120	50	138	50	127	50	135	50	155	50	134	50	124	50	109	50	117	50	96
23	Pacific.......	Jan 30–31	38.5 S	222.0	15	136	15	123	15	146	15	119	15	119	15	131	15	147	15	147	15	176	15	158
24	Atlantic.....	Feb 20–21	51.6 S	297.1	09	156	09	166	09	191	09	206	09	210	09	216	09	213	09	193	09	167	09	182
		1918																						
25	Pacific.......	Jan 9–10	38.5 S	284.3	52	134	52	138	51	169	52	153	52	200	52	180	55	167	51	151	47	163	53	159
26	Pacific.......	Jan 31–32	30.3 S	272.4	38	153	41	172	38	143	38	172	40	104	37	186	36	151	35	131	30	129	35	130
27	Pacific.......	Feb 17–18	19.2 S	281.0	02	182	06	177	05	182	04	161	07	161	07	181	04	171	02	192	05	228	09	185
28	Pacific.......	Apr 10–11	10.0 S	266.4	00	107	−05	109	00	117	00	98	00	109	00	100	00	107	00	94	−02	98	−01	107
29	Pacific.......	Apr 18–19	0.7 N	277.5	20	136	16	156	16	139	15	128	16	136	16	140	16	160	14	155	15	151	17	158
		1919																						
30	Atlantic.....	Dec 30–31	15.8 S	341.8	34	136	12	(128)	−12	121	−10	108	−06	138	−04	144	07	148	[2]12	[2]139	15	111	26	91
		1920																						
31	Atlantic.....	Mar 16–17	30.4 S	3.8	44	86	17	(93)	−11	100	−01	92	04	81	25	84	15	72	22	163	[1]37	60	38	59
32	Atlantic.....	Apr 8– 9	24.6 S	345.7	23	(69)	−03	74	06	54	43	66	49	64	34	(64)	19	63	49	94	24	(98)	[1]−01	100
33	Atlantic.....	Apr 19–20	36.4 S	6.4	04	72	02	79	03	63	10	(67)	16	69	05	66	36	71	[1]52	84	44	(76)	35	67
34	Indian.......	Jun 17–18	0.5 N	62.8	21	(111)	−03	106	−03	107	[1]−34	110	−02	76	−07	107	−05	88	05	88	09	76	33	85
35	Indian.......	Aug 9–10	15.2 S	90.0	43	111	23	(101)	[1]11	101	28	100	41	109	17	(109)	−06	109	20	115	22	102	18	117
36	Indian.......	Aug 18–19	29.8 S	74.6	−03	94	04	83	[1]−08	63	10	73	04	62	01	67	−02	73	−06	74	11	70	08	74
37	Indian.......	Oct 8– 9	45.2 S	128.1	13	79	−06	(71)	[1]−26	62	−13	77	−16	(74)	−20	71	−03	71	−02	86	07	106	15	108
38	Indian.......	Oct 11–12	50.1 S	140.2	[1]19	100	30	(95)	30	(91)	34	88	15	(95)	−05	101	−06	101	10	(99)	22	98	15	(90)
39	Pacific.......	Nov 23–24	46.4 S	188.6	18	117	20	(125)	39	132	40	120	56	132	48	(138)	40	144	49	148	40	(142)	31	136
40	Pacific.......	Nov 30	43.8 S	210.8	[1]54	74	20	(74)	09	73	15	74	15	(82)	15	87	12	75	17	84	18	71	14	66
41	Pacific.......	Dec 9–10	30.8 S	228.4	18	(71)	−02	63	−06	69	−04	70	08	57	06	60	03	57	34	68	44	56	53	76
		1921																						
42	Pacific.......	Jan 10–11	3.0 S	205.6	44	74	20	(75)	−10	76	−07	82	−06	102	−10	83	00	74	00	86	01	75	04	92
43	Pacific.......	Jan 29–30	32.7 N	188.9	07	80	08	94	10	77	10	68	00	(72)	−24	76	−16	76	−14	103	−13	120	−15	96
44	Pacific.......	Feb 18–19	38.0 N	234.4	40	(104)	20	109	50	101	50	87	49	88	48	86	52	87	51	93	30	(92)	11	92
45	Pacific.......	Apr 9–10	23.0 N	210.0	14	77	10	77	05	77	00	(76)	−02	73	41	67	30	(59)	16	52	38	58	35	(65)
46	Pacific.......	May 9–10	33.6 N	207.8	41	119	27	90	17	(88)	07	87	07	(107)	07	129	37	132	37	(134)	37	137	30	[illegible]
47	Pacific.......	May 16–17	28.0 N	221.8	18	82	09	75	28	73	15	(69)	01	64	35	81	20	(82)	04	83	28	92	15	[illegible]
48	Pacific.......	May 23–24	13.9 N	224.2	12	96	02	85	−10	(81)	−21	76	07	84	−10	(87)	−27	88	03	86	25	101	00	[illegible]
49	Pacific.......	Jun 2– 3	2.2 N	212.6	32	111	32	102	20	(105)	06	106	00	(101)	−16	98	16	102	00	(104)	47	105	17	109
50	Pacific.......	Jun 7– 8	4.0 S	206.9	04	117	00	(109)	−17	99	31	96	20	(92)	06	88	00	(94)	−19	102	23	85	00	(86)
51	Pacific.......	Jun 17–18	11.8 S	195.5	24	(104)	10	96	09	87	09	96	00	(95)	−01	93	35	76	24	(80)	02	85	00	(87)
52	Pacific.......	Jul 29–30	17.0 S	188.2	34	123	31	108	00	(106)	−22	104	−12	102	−03	98	14	107	31	115	37	139	00	(133)
53	Pacific.......	Aug 23–24	29.0 S	216.6	43	85	44	81	23	(78)	02	74	12	78	13	66	14	83	19	83	15	81	12	88
54	Pacific.......	Aug 30–31	29.4 S	228.9	30	101	26	86	21	90	27	79	34	68	31	82	23	75	19	70	08	70	04	82
55	Pacific.......	Sep 14–15	24.5 S	258.4	10	86	02	89	−08	92	−11	100	−12	95	−13	88	−10	86	−14	95	−18	107	−16	89
56	Pacific.......	Sep 21–22	4.7 S	260.2	−12	112	−04	93	09	102	07	89	10	107	21	87	13	92	20	89	26	96	00	(98)
57	Pacific.......	Sep 28–29	2.4 N	271.0	39	32	39	43	42	48	40	55	32	20	29	45	24	60	30	67	25	64	20	87
58	Atlantic.....	Oct 23–24	15.3 N	284.5	42	100	43	105	31	114	20	(120)	08	124	04	90	−07	94	10	105	14	100	00	(101)
59	Atlantic.....	Nov 1– 2	32.0 N	285.3	12	106	12	91	18	116	−12	(104)	−24	89	−18	91	−18	96	00	(100)	06	104	00	(104)

[1] Time of first determination in the series.

[2] Time and value given are means for first determination and for one at the corresponding hour at end of the series.

Consideration of curves *A*, *B*, and *C* of Figure 23 leaves little room for doubting that the best approximation to the mean result of the ten series of observations would be obtained by the adoption of a common basis of time. Accordingly, curve C' is the mean curve obtained from the same ten series of observations as used for curve *C*, the only difference being that here each individual set of observations was referred to G. M. T. before tabulation. It is apparent, from curve C', that the adoption of a common

Variation Series of Atmospheric Potential-Gradient Observed on the Carnegie, 1915-1921.

Greenwich mean times and observed values of atmospheric potential-gradient.

10^h	P	11^h	P	12^h	P	13^h	P	14^h	P	15^h	P	16^h	P	17^h	P	18^h	P	19^h	P	20^h	P	21^h	P	22^h	P	23^h	P	P_m
m	v/m	m	v/m	m	v/m	m	v/m	m	v/m	m	v/m	m	v/m	m	v/m	m	v/m	m	v/m	m	v/m	m	v/m	m	v/m	m	v/m	v/m
38	128	38	119	46	108	44	124	46	99	44	148	40	157	38	154	38	141	38	156	38	150	38	154	38	191	38	166	132
56	131	56	114	56	111	56	137	56	122	56	151	56	138	56	112	56	22	56	112	[1]44	180	44	186	44	168	56	180	136
27	108	27	91	27	110	27	120	27	119	27	135	27	125	27	124	27	160	27	171	27	165	[1]27	160	27	163	27	164	128
41	88	41	98	41	106	41	105	41	92	41	98	41	84	41	94	41	130	41	163	41	161	[1]41	174	41	170	41	111	112
45	111	45	146	45	150	45	197	45	177	45	200	42	149	53	(163)	53	(146)	53	(128)	53	(103)	[1]45	111	45	91	45	92	127
04	109	04	125	04	148	04	149	04	172	04	163	04	158	04	150	04	146	04	178	04	106	04	102	[1]04	154	04	130	134
43	108	43	140	43	158	43	133	43	161	43	167	43	136	37	155	37	134	[1]43	177	43	124	43	120	43	102	43	104	127
56	(200)	[1]56	228	56	209	56	201	56	208	56	227	56	227	56	227	56	188	56	239	56	230	56	215	56	193	56	154	191
33	151	33	171	33	175	33	172	33	176	33	201	33	171	33	184	33	179	33	216	33	161	33	164	33	149	33	157	164
10	187	10	190	10	164	10	217	10	219	10	243	10	216	10	186	10	247	10	171	16	128	19	(192)	22	(187)	27	(182)	187
40	148	40	126	40	166	40	167	40	138	40	247	40	175	40	185	40	228	40	285	40	205	40	269	32	257	[1]40	141	163
22	107	20	160	17	141	17	140	17	156	17	171	17	164	17	174	18	181	17	141	[1]17	141	17	138	17	130	17	134	144
18	112	18	102	18	110	18	107	18	114	18	118	18	108	18	115	18	143	18	150	[1]22	140	18	157	18	131	18	139	125
51	138	49	130	42	153	38	151	42	143	41	161	27	(162)	27	(162)	27	(162)	27	(162)	[1]42	149	47	143	42	143	42	124	142
40	98	40	109	40	58	40	64	40	88	40	100	34	100	40	118	36	139	[1]40	266	40	190	40	125	40	89	40	109	115
01	138	01	115	01	153	01	112	01	126	01	155	01	140	01	146	[1]01	181	01	157	01	127	01	151	01	162	01	174	132
22	177	22	196	22	217	22	234	22	215	22	259	[1]22	165	22	184	22	188	22	180	22	161	22	216	22	177	22	143	174
08	138	08	153	08	169	08	191	08	188	08	196	[1]08	149	08	148	08	130	08	164	08	150	08	145	08	149	08	124	135
04	145	04	153	04	167	04	174	04	166	04	155	04	166	[1]04	51	04	53	04	155	04	167	04	171	04	162	04	170	152
54	90	54	93	54	111	48	77	56	147	54	117	[1]54	151	54	135	54	153	54	127	54	140	54	127	54	124	54	116	108
30	98	30	95	30	94	30	135	30	99	30	107	[1]30	115	30	134	30	104	30	115	30	107	30	102	30	107	30	91	105
50	135	50	132	50	126	50	140	50	173	50	173	50	181	[1]57	177	50	147	50	169	50	139	50	150	50	143	50	131	140
15	151	15	156	15	213	15	172	15	200	15	205	15	193	15	186	[1]15	277	15	216	15	211	15	167	15	165	15	150	169
12	(176)	15	169	09	208	[1]09	268	09	277	09	288	09	281	09	260	09	294	09	248	09	217	09	190	09	149	09	156	212
55	185	53	318	45	300	[1]59	150	51	105	52	185	52	136	51	204	51	263	52	225	58	163	57	171	50	166	48	142	180
33	129	34	185	36	146	36	174	[1]36	169	37	130	36	119	35	140	35	131	33	162	38	177	38	155	38	145	39	156	145
05	207	04	212	08	218	−04	289	[1]03	243	05	222	05	324	06	320	05	319	07	335	06	309	07	300	04	272	09	197	233
02	102	00	119	10	135	00	144	−01	144	[1]00	133	00	160	00	134	00	128	00	124	00	136	00	146	−01	128	00	93	120
17	146	18	146	17	176	16	210	[1]16	162	16	170	16	177	16	176	16	170	16	160	16	145	17	149	16	124	16	129	154
28	89	33	100	34	126	32	126	45	90	39	108	38	155	10	(160)	−01	164	−02	148	22	156	32	149	29	(130)	26	112	128
24	88	35	87	32	107	41	94	41	105	35	114	35	90	38	120	15	(121)	−08	123	−02	70	01	101	18	120	25	126	98
−01	108	01	106	21	106	21	107	09	(109)	−03	113	−03	126	−05	93	13	102	13	80	40	99	43	(86)	45	74	49	65	88
26	65	31	90	51	85	25	(83)	02	81	−05	88	−05	87	−04	96	−34	114	−20	(107)	−21	101	−15	75	−09	87	−05	80	81
26	78	32	66	32	88	15	(75)	−11	88	−07	92	00	119	03	126	02	113	02	110	04	117	21	132	30	111	44	116	99
41	108	24	(107)	08	106	35	117	22	(102)	18	88	06	(101)	−06	114	20	115	47	126	32	(130)	16	133	11	(131)	06	127	112
−04	68	−05	57	−06	63	−05	(69)	−04	74	−02	94	08	80	00	(81)	−09	83	−08	108	00	98	29	86	36	103	16	(99)	79
09	(111)	03	(112)	−03	(114)	02	(117)	07	114	13	113	24	98	24	148	10	(124)	−03	136	14	(135)	−32	132	−24	136	−15	116	105
15	(85)	07	74	21	101	36	107	20	(140)	04	177	11	157	22	295	30	(275)	27	264	20	(180)	01	97	00	(105)	−06	113	130
40	170	48	170	56	164	58	160	40	(155)	24	151	50	110	62	129	[1]23	249	10	(215)	−02	182	04	153	31	144	20	(130)	151
35	76	46	83	28	79	35	(79)	43	(80)	−09	81	03	79	24	98	25	(109)	25	119	28	110	35	83	40	86	42	77	83
35	(85)	35	(95)	39	102	59	117	[1]28	133	32	119	35	117	42	124	44	107	51	107	57	101	40	(100)	23	99	29	84	89
06	84	−01	107	−08	108	22	96	40	98	20	(96)	−02	94	[2]−04	[2]104	13	109	11	(105)	08	99	12	92	31	89	35	84	91
00	(95)	15	99	19	98	15	98	15	118	−01	(114)	−18	110	−11	(107)	−04	(103)	[1]02	100	−11	(103)	−24	106	−06	87	03	70	94
35	114	20	(126)	06	139	24	136	27	114	44	172	25	(155)	[1]02	137	17	167	28	161	35	143	32	137	43	113	55	100	119
33	71	20	(59)	−08	58	28	58	28	(63)	27	65	20	(50)	14	34	[1]19	68	10	(71)	00	(73)	−10	74	00	(76)	05	78	66
28	108	00	(101)	00	(95)	−03	88	00	(95)	01	100	37	99	[1]23	123	10	(117)	06	109	00	(104)	−12	98	15	109	46	114	109
01	95	31	101	30	(99)	28	95	20	(101)	17	108	30	100	[2]09	[2]104	26	89	10	(95)	−05	101	29	83	25	(83)	22	84	89
−13	99	11	78	00	(82)	−05	85	49	88	[1]32	81	20	(88)	09	99	00	(94)	−05	91	36	113	30	(118)	22	122	14	99	93
00	(107)	−15	115	14	94	00	(100)	−02	106	53	115	[1]22	122	24	(123)	26	124	20	(127)	18	132	00	(126)	−04	120	38	120	111
00	(88)	15	92	03	84	00	(95)	−18	104	−14	(113)	−10	121	[1]−10	124	35	130	30	(132)	19	135	00	(142)	07	146	00	(132)	109
−12	90	00	(79)	−13	72	15	73	00	(86)	01	105	00	(112)	−04	118	46	109	[1]28	139	24	(126)	25	111	30	(112)	24	113	98
−16	136	−10	138	−08	154	−06	117	00	(117)	00	(118)	00	(119)	00	(119)	[1]10	120	26	121	31	151	28	152	30	131	34	126	128
10	100	21	85	18	92	28	85	29	92	32	97	34	86	[2]36	[2]103	46	129	48	125	42	111	39	97	38	97	44	87	91
−05	88	08	94	12	94	14	101	26	112	[2]40	[2]104	43	118	53	101	51	120	45	129	40	124	32	132	31	123	32	100	98
00	101	15	(98)	29	96	[1]61	104	54	88	54	109	50	95	44	106	36	99	26	114	26	142	28	106	25	87	18	87	97
−14	90	−06	90	18	131	35	92	[1]−15	90	−16	98	−12	83	−01	134	−09	115	−12	126	−24	139	−26	117	23	80	00	(96)	102
18	80	18	71	05	60	[2]06	[2]79	19	60	27	56	32	54	29	23	37	38	42	42	43	71	39	56	35	54	31	43	58
−11	102	−05	105	−12	106	00	109	[1]−33	131	−27	134	03	159	06	176	13	167	28	180	39	136	38	138	45	111	46	107	121
00	(104)	00	(104)	[1]06	104	12	104	00	(140)	−24	187	−18	139	−12	150	−06	(135)	−24	125	−18	155	−12	126	06	111	12	116	117

[1] Time of first determination in the series.

[2] Time and value given are means for first determination and for one at the corresponding hour at end of the series.

time basis is warranted and also that, so far as the *Carnegie* observations are concerned, a relatively small number of ocean series appear to give rather more dependable means than one would be likely to expect on the basis of experience with data from land observations.

TABLE 77.—*Dates and Mean Positions Corresponding to Diurnal-Variation Observations for Potential Gradient Aboard the Carnegie, 1915-1921.*

Date	Lat.	Long. east of Gr.	Ocean	Mean value *P*	Date	Lat.	Long. east of Gr.	Ocean	Mean value *P*
	°	°		v/m		°	°		v/m
Jan 28–29, 1916.......	53.1 S	33.8	Indian	191	Jul 7–8, 1915........	30.6 N	198.7	Pacific	132
Jan 8–9, 1917.........	12.5 S	244.9	Pacific	105	Jul 2–3, 1916........	15.1 N	176.2	Do.	142
Jan 18–19, 1917.......	22.2 S	226.3	Do.	140	Jul 29–30, 1921......	17.0 S	188.2	Do.	123
Jan 30–31, 1917.......	38.5 S	222.0	Do.	169					
Jan 9–10, 1918........	38.5 S	284.3	Do.	180	Aug 13–15, 1915[1]......	57.0 N	178.2	Pacific	136
Jan 31–Feb 1, 1918....	30.3 S	272.4	Do.	145	Aug 9–10, 1920.......	15.2 S	90.0	Indian	112
Jan 10–11, 1921.......	3.0 S	205.6	Do.	91	Aug 18–19, 1920......	29.8 S	74.6	Do.	79
Jan 29–30, 1921.......	32.7 N	188.9	Do.	94	Aug 23–24, 1921......	29.0 S	216.6	Pacific	91
					Aug 30–31, 1921......	29.4 S	228.9	Do.	98
Feb 16–17, 1916.......	34.5 S	96.0	Indian	164					
Feb 25–26, 1916.......	48.2 S	104.1	Do	187	Sep 3–4, 1915........	27.3 N	169.8	Pacific	128
Feb 20–21, 1917.......	51.6 S	297.1	Atlantic	212	Sep 16–17, 1915......	13.8 N	166.3	Do.	112
Feb 17–18, 1918.......	19.2 S	281.0	Pacific	233	Sep 4–5, 1916........	52.1 N	197.0	Do.	115
Feb 18–19, 1921.......	38.0 N	234.4	Do.	119	Sep 14–15, 1916......	40.9 N	221.8	Do.	132
					Sep 14–15, 1921......	24.5 S	258.4	Do.	97
Mar 20–21, 1916......	57.0 S	140.0	Indian	163	Sep 21–22, 1921......	4.7 S	260.2	Do.	102
Mar 16–17, 1920......	30.4 S	3.8	Atlantic	98	Sep 28–29, 1921......	2.4 N	271.0	Do.	53
Apr 10–11, 1918.......	10.0 S	266.4	Pacific	120	Oct 9–10, 1915.......	9.8 S	162.7	Pacific	127
Apr 18–19, 1918.......	0.7 N	277.5	Do.	154	Oct 16–17, 1915......	21.9 S	157.2	Do.	134
Apr 8–9, 1920.........	24.6 S	345.7	Atlantic	88	Oct 8–9, 1920........	45.2 S	128.1	Indian	105
Apr 19–20, 1920........	36.4 S	6.4	Do.	81	Oct 11–12, 1920......	50.1 S	140.2	Do.	130
Apr 9–10, 1921........	23.0 N	210.0	Pacific	66	Oct 23–24, 1921......	15.3 N	284.5	Atlantic	121
May 26–27, 1916......	32.6 S	187.0	Pacific	144	Nov 9–10, 1916.......	20.7 N	243.4	Pacific	174
May 9–10, 1921.......	33.6 N	207.8	Do.	109	Nov 29–30, 1916......	3.4 N	246.0	Do.	135
May 16–17, 1921......	28.0 N	221.8	Do.	89	Nov 23–24, 1920......	46.4 S	188.6	Do.	151
May 23–24, 1921......	13.9 N	224.2	Do.	93	Nov 29–30, 1920......	43.8 S	210.8	Do.	88
					Nov 1–2, 1921........	32.0 N	285.3	Atlantic	117
Jun 23–24, 1916.......	2.9 S	187.6	Pacific	125					
Jun 17–18, 1920.......	0.5 N	62.8	Indian	99	Dec 30–31, 1915......	59.0 S	272.8	Pacific	127
Jun 2–3, 1921.........	2.2 N	212.6	Pacific	111	Dec 7–8, 1916........	13.7 S	234.4	Do.	152
Jun 7–8, 1921.........	4.0 S	206.9	Do.	109	Dec 15–16, 1916......	28.2 S	237.8	Do.	108
Jun 17–18, 1921.......	11.8 S	195.5	Do.	98	Dec 30–31, 1919......	15.8 S	341.8	Atlantic	128
					Dec 9–10, 1920.......	30.8 S	228.4	Pacific	89

[1] Crossed 180th meridian.

If we now refer to G. M. T. each 20-minute set of observations throughout all 24-hour series and derive new mean hourly values for each ocean for all observations between G. M. T. 0^h and 1^h, 1^h and 2^h, ..., 23^h and 24^h, it is found that the resulting mean curves have the following outstanding features: (1) there is general similarity as to form, each roughly approximating a sine curve; (2) the ranges between extreme values are greatly increased (actually from 10 to 20 per cent for the curves under consideration); and (3) there is approximate agreement as to phase and, therefore, as to G. M. T. of maximum and minimum, respectively.

During the years 1915 to 1921, 59 usable diurnal-variation series were obtained on the *Carnegie* for the potential gradient. Table 76 shows serial number, date, mean position, observed hourly values on G. M. T., and mean-of-day value corresponding to each of these series, of which 7 were in the Atlantic Ocean, 9 in the Indian, and 43 in the Pacific. Where there were less than 24 hourly sets of observations in a diurnal-variation series, interpolations were made for the missing hours to eliminate, so far as

possible, error in the mean hourly values due to changes in absolute value from day to day. All interpolated values are inclosed in parentheses.

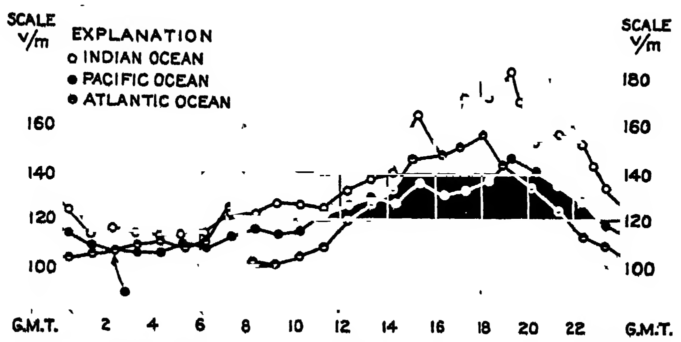

FIG. 24.—Mean Value of the Potential Gradient for the Different Oceans from Observations on the *Carnegie*, 1915–1921.

The graphs in Figure 24 represent for each ocean the mean values of the atmospheric potential-gradient for each hour of the Greenwich day. However, one may only conclude from these curves that the mean daily changes in potential gradient from observations scattered throughout the different parts of the year are, in general, much the same over the three major oceans. Further, no account is taken in these curves of possible changes in the diurnal variation with time of year, or with latitude, and it is assumed that the nature of the daily changes is practically constant from year to year. It remains, therefore, to make a more detailed examination of these data in order to determine if the curves for the several oceans represent more than merely a statistical average of heterogeneous material, and to what extent detailed analyses of subsidiary mean values may be justifiable.

TABLE 78.—*Dates and Mean Positions of Seven Diurnal-Variation Series for Potential Gradient of the Atmosphere as Used for Detailed Study in Figure 25.*

Dates	Lat.	Long. E. of Gr.	Mean curve, Fig. 25	Remarks regarding evidence indicated by mean curves
	°	°		
Feb 16–17, 1916	34.5 S	96.0	A	*A* and *B:* Approximately same diurnal variation for stations of southern latitude, but in different oceans and for same time of year.
Feb 25–26, 1916	48.2 S	104.1		
Feb 17–18, 1918	19.2 S	281.0	B	*B* and *D:* Similar variation for north and south latitude at same time of year.
Apr 10–11, 1918	10.0 S	266.4		
Mar 16–17, 1920	30.4 S	3.8	C	*A* and *B* with *C* and *D:* Approximately similar diurnal variation in three different oceans; approximately same diurnal variation for 1916–18 as for 1920–21, and practically no change in diurnal variation with change in absolute value.
Apr 8–9, 1920	24.6 S	345.7		
Apr 19–20, 1920	36.4 S	6.4		
Feb 18–19, 1921	38.0 N	234.4	D	*C* and *D:* Diurnal variation similar in North Pacific and South Atlantic oceans at same time of year.
Apr 9–10, 1921	23.0 N	210.0		

In view of our ignorance of the cause or causes of the diurnal variation of the atmospheric potential-gradient, any knowledge we may be able to obtain regarding either the constancy of or possible changes in its characteristic features during the progress of the year is a matter of considerable interest. The results obtained during the months of February, March, and April, 1915–1921, appeared to be especially well suited to test the legitimacy of combining data from widely separated regions, since several series of diurnal-variation observations were obtained during these months in both the northern and southern hemispheres and in each of the chief oceans. In the first four columns of Table 78 are shown the actual series used, their dates, positions, and how they were combined to form the curves of Figure 25 for comparative study. If one takes into

account the small number of 24-hour series (only two or three) involved in each curve and the disturbances and irregular fluctuations to which the potential gradient is subject, the agreement of the four curves appears much better than one would expect.

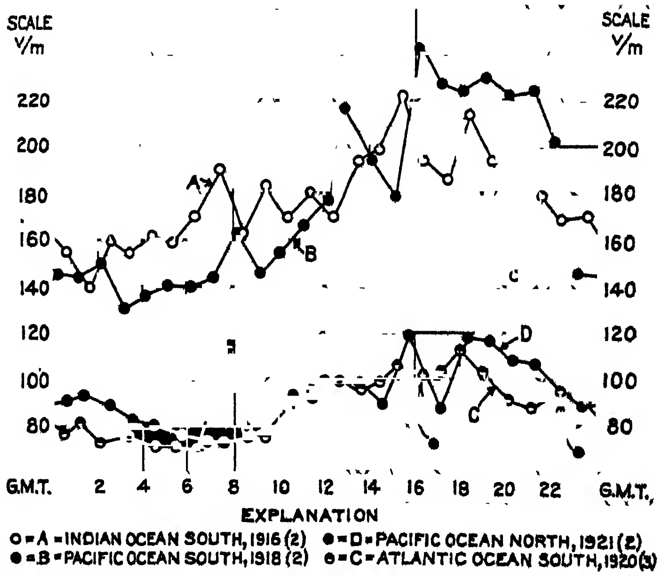

FIG. 25.—Comparison of Diurnal Variation of Potential Gradient for Same Time of Year in Different Oceans and in Different Latitudes.

In the last column of Table 78 are summarized the chief conclusions resulting from the comparisons of the curves of Figure 25 in various combinations. From these it appears that the general features of the diurnal variation of the atmospheric potential-gradient, at a given time of year, are approximately the same in each of the oceans and for both northern and southern latitudes. They also indicate that, despite a marked reduction in the absolute value of the potential gradient between 1916 and 1921 (to be discussed later), the relative values throughout the day, expressed as percentages of the mean-of-day value, remained roughly the same.

In view of the foregoing results, mean diurnal-variation curves were formed for each month, the curve for any given month being based on all the diurnal-variation series given in Table 76 for that month. For convenience of reference the chief facts regarding the diurnal-variation series are summarized in Table 77, where the series for each month during 1915 to 1921 are grouped together. Although the mean curves corresponding to the monthly groups are not reproduced here, a word should be said regarding their general nature. While perhaps none of them is more than a rough approximation of what would be obtained from a large number of observational series, it is believed that, taken together, they do give a fair representation of the main features of the diurnal variation of the potential gradient over the ocean for different parts of the year. In general the annual cycle of changes in the diurnal variation indicated by the monthly curves is similar to that which occurs at various stations of western and central Europe, as, for example, at Potsdam.

There is, however, a marked difference between the ocean results and the Potsdam results as regards the relative importance of the 24-hour and other waves at different times of year. For example, at Potsdam the 12-hour wave becomes increasingly prominent from February to midyear, after which it decreases until November, while the 24-hour wave is more or less masked by the 12-hour one except in January and December. Over the oceans, on the contrary, the mean monthly curves indicate that the 24-hour wave predominates for about three-fourths of the year, while the 12-hour wave appears

to be either non-existent or at least so small as to be practically negligible, except during the months May to July, inclusive. The graph at the bottom of Figure 26 represents the yearly mean diurnal-variation curve derived from the 59 diurnal-variation series on the *Carnegie* for the years 1915 to 1921.

TABLE 79.—*Summary of Diurnal-Variation Results in Potential Gradient of the Atmosphere as Obtained on the Carnegie, 1915 to 1921.*

G. M. T.	Feb, Mar, Apr (12 series)		May, Jun, Jul (12 series)		Aug, Sep, Oct (17 series)		Nov, Dec, Jan (18 series)		General mean Feb to Jan (59 series)	
	P	Δ*P*	*P*	Δ*P*	*P*	Δ*P*	*P*	Δ*P*	*P*	Δ*P*
h	*v/m*	*v/m*	*v/m*	*v/m*	*v/m*	*v/m*	*v/m*	*v/m*	*v/m*	*v/m*
1	120	−20	105	− 9	104	− 6	115	−17	110	−14
2	123	−17	101	−13	100	−10	114	−18	109	−15
3	120	−20	101	−13	98	−12	113	−19	108	−16
4	119	−21	101	−13	96	−14	113	−19	107	−17
5	118	−22	104	−10	93	−17	119	−13	108	−16
6	119	−21	108	− 6	93	−17	118	−14	109	−15
7	128	−12	111	− 3	97	−13	117	−15	113	−11
8	127	−13	117	+ 3	98	−12	122	−10	116	− 8
9	124	−16	115	+ 1	97	−13	123	− 9	114	−10
10	128	−12	109	− 5	100	−10	123	− 9	116	− 8
11	132	− 8	107	− 7	99	−11	134	+ 2	120	− 4
12	141	+ 1	107	− 7	104	− 6	146	+14	125	+ 1
13	157	+17	104	−10	108	− 2	146	+14	128	+ 4
14	156	+16	106	− 8	111	+ 1	144	+12	130	+ 6
15	166	+26	115	+ 1	119	+ 9	151	+19	138	+14
16	169	+29	123	+ 9	116	+ 6	146	+14	137	+13
17	162	+22	127	+13	123	+13	143	+11	139	+15
18	174	+34	128	+14	129	+19	149	+17	143	+19
19	174	+34	128	+14	140	+30	156	+24	150	+26
20	154	+14	129	+15	140	+30	152	+20	146	+22
21	155	+15	130	+16	129	+19	145	+13	138	+14
22	149	+ 9	127	+13	121	+11	137	+ 5	133	+ 9
23	130	−10	123	+ 9	116	+ 6	126	− 6	124	− 0
24	121	−19	115	+ 1	110	0	118	−14	117	− 7
Means, P_m	140	....	114	....	110	....	132	....	124	....

It was apparent from the monthly mean curves that a division of the year into 3-month periods approximately symmetrical about the solstices and equinoxes would result in the grouping together of those months which showed the greatest similarity as regards the diurnal variation of the potential gradient. As the result of such grouping there are 12 series of diurnal-variation observations available for establishing a mean curve for February, March, and April, 12 series for May, June, and July, 17 for August, September, and October, and 18 for November, December, and January.[a] In Figure 26 are given mean curves as derived from the data in Table 76 for each of these 3-month periods as follows: (*a*) a mean curve from all diurnal-variation series of Cruise IV or cruises IV and V; (*b*) a similar subsidiary mean curve based on the observations of Cruise VI only; and (*c*) a mean curve, the heavy middle curve of each group, based on all observations during the respective months throughout cruises IV, V, and VI. The mean curve deduced from all 59 series for the 12-month period is given at the bottom of Figure 26. The values given in Table 79 for the Greenwich hours are scaled from the heavy curves of Figure 26.

[a] The numbers of series here allotted to the several 3-month periods differ slightly from those given in *Terr. Mag.* vol. 26 (1923), pp. 61–81, as follows: For the May-June-July period the series thought to have been obtained on June 8 and 9, 1920, was found from the original records to have been discontinuous by a matter of 24 hours and was, therefore, rejected; also, the series for November 1 and 2, 1921, was added to the November-December-January group.

It is realized, of course, since the mean curves are not derived from observations made at one place or in the same ocean, that even the general mean curves for the several 3-month periods are only approximate ones and that undoubtedly they will be modified somewhat as to detail when additional diurnal-variation data become available. However, a comparison of the two subsidiary mean curves for each 3-month period

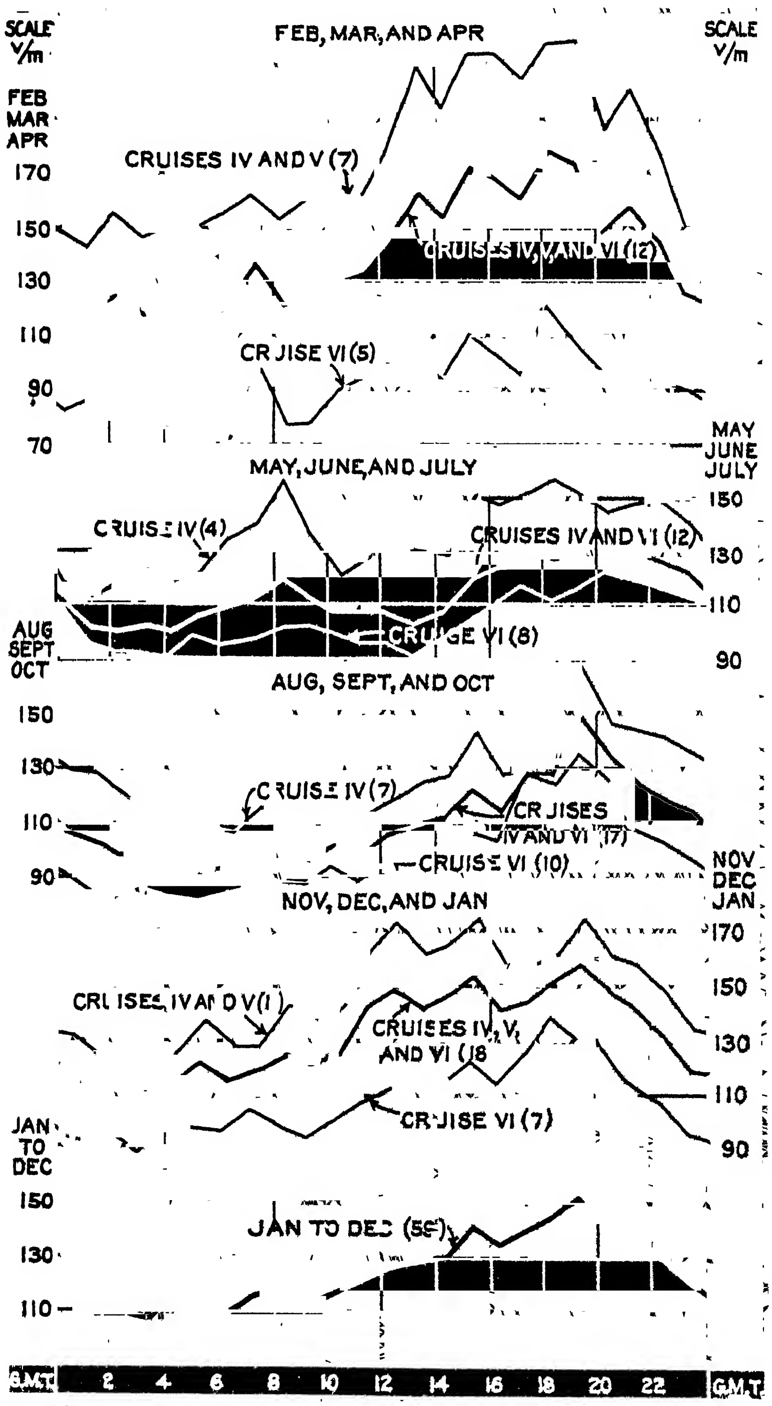

FIG. 26.—Mean Diurnal-Variation of Potential Gradient for Three-Month Periods from Diurnal-Variation Series on the *Carnegie*, Cruises IV, V, and VI, 1915–1921.

indicates that no changes of great moment are to be expected with the acquirement of additional data.

In order to obtain approximate numerical measures of the characteristic features of the diurnal variation of the potential gradient as derived from the *Carnegie* observations and of their changes during the progress of the year, and also to facilitate comparison between land and ocean results, the data represented by the heavy curves of Figure 26 and tabulated in Table 79 have been analyzed by the method of Fourier. Following the usual practice, it is assumed, that the value of the potential gradient P is given at any time by the expression

$$P = P_m + c_1 \sin(\theta + \phi_1) + c_2 \sin(2\theta + \phi_2) + c_3 \sin(3\theta + \phi_3) + \ . \ . \ . \qquad (1)$$

θ being counted from 0^h midnight G. M. T., at the rate of 15° per hour. The results of the analyses for the solstitial and equinoctial quarters and for the entire year are given in Table 80, where the amplitudes, c, are expressed in volts per meter and in percentages of P_m, the mean-of-day value. It should be noted that all potential-gradient values shown in the graphs and tables of this report are of the order of 20 to 25 per cent greater than those given in the author's earlier papers to which references have been made. The occasion for these changes was discussed on pages 387 and 388.

TABLE 80.—*Results of Fourier Analysis of the Diurnal Variation of the Potential Gradient (P) from Observations Aboard the Carnegie, 1915-1921.*

Months	P_m	ϕ_1	ϕ_2	ϕ_3	ϕ_4	c_1		c_2		c_3		c_4		c_2/c_1
	v/m	°	°	°	°	v/m	p. ct.	v/m	p. ct.	v/m	p. ct.	v/m	p. ct.	
Feb–Apr.......	140	197	279	317	337	26.0	19	6.3	4	1.9	1	2.5	2	0.24
May–July.....	114	166	212	100	196	10.6	9	8.6	8	2.8	2	1.5	1	0.81
Aug–Oct.......	110	167	217	278	345	18.7	17	5.5	5	2.0	2	2.5	2	0.29
Nov–Jan.......	132	202	224	242	4	19.5	15	2.7	2	4.9	4	1.8	1	0.14
Year....	124	187	226	242	342	18.0	15	5.0	4	1.7	1	1.4	1	0.28

From Table 80, and also from the curves of Figure 26, it is obvious that the 24-hour wave continues, throughout the year, to be the predominating feature of the diurnal variation. Whether or not the apparent annual variation of ϕ_1 is real is, of course, a question whose settlement must await the results of further observational work over the oceans. It is of interest to note, however, that the departures of ϕ_1 for the May-June-July quarter and the November-December-January quarter, respectively, from ϕ_1 for the yearly mean are similar in sense and magnitude to what is found at many land stations.[a]

As regards the amplitudes of the waves, the most striking fact brought out by the analysis is the marked diminution of c_1 and increase of c_2 during the May-June-July quarter similar to what is observed at most land stations, the ratio c_2/c_1 during this quarter being in fact more than five times as large as during the November-December-January quarter.

Unfortunately, the geographical distribution of the observations for the May-June-July quarter is not so good as one might wish, since 11 of the 12 series of observations were made in a relatively small part of the Pacific Ocean (between latitudes 35° N and 25° S and longitude 165° E and 240° E) and do not, therefore, represent the ocean as a whole. While the remaining series, which was obtained in the Indian Ocean, shows a secondary maximum at about 6^h to 8^h G. M. T., it is not so marked as in the observations from the Pacific. It is significant, however, that the subsidiary mean curves of Figure 26 from the observations of May-July during cruises IV and VI,

[a] See *Terr. Mag.*, vol. 28 (1923), pp. 61–81.

respectively, are in fair agreement as to the essential features of the diurnal variation during this part of the year.

The good agreement of the May-July curve from the observations of Cruise IV with that obtained from the observations of Cruise VI points rather strongly to the existence at this time of year of a 12-hour wave whose amplitude is large as compared with what is found from the other mean curves for 3-month periods. It is, therefore, pertinent to inquire regarding the nature of the diurnal variation of the potential gradient *in this same region* during the remainder of the year. Fortunately, of the 17 series for August-October, 6 represent approximately the same region as the May-July curve; and of the 18 series for the November-January period, 7 were obtained in the area under discussion. In both cases the subsidiary mean curves resemble the yearly mean curve and the respective quarterly curves much more closely than they resemble the May-July curve. In other words, for the area in which the observations of May-July were made, the diurnal variation of the potential gradient during the six months of the year for which comparative data are available is practically identical with that derived from all oceans, as given in Figure 26, for the same months (August-October and November-January). Consequently, so far as the Pacific Ocean is concerned, the evidence from the data in hand is entirely in favor of the reality of the double maximum type of curve for the three months May-July. For the remainder of the year, however, the single-maximum type with only a small amplitude for the 12-hour wave appears to predominate for all oceans.

Attention was directed by Lüdeling[a] to the importance of ocean diurnal-variation observations for supplying evidence regarding the correctness of Ebert's[b] hypothesis of a causal relation between the diurnal-variation of the barometric pressure and the potential gradient. Such evidence is particularly desirable, since it has been found by Chree[c] that the pressure curve at Kew, especially in the afternoon, shows a considerable lag with reference to the potential-gradient curve, whereas, according to Ebert's hypothesis, the pressure curve should always lead. Although Neumayer[d] did not call attention to the fact, an examination of the published results of his registration of both potential gradient and atmospheric pressure at Melbourne, 1856-1862, shows the same effect, the pressure curve in this case also lagging from one to three hours behind the potential-gradient curve. Despite the obvious need for evidence on this point from ocean observations, it turns out that no *direct* evidence is available from the observations to date, since the amplitude of the second harmonic over the oceans has been found large enough for definite comparisons only during the three months May-July, which is also the quarter for which the regional distribution of the stations (as given above) is least favorable for such a study. This is due to the fact that, for the relatively limited region in which the May-July data were obtained, the two daily maxima occur, on the average, at about the same *local times* as in western Europe, since the difference in local time with reference to the European stations is of the order of 12 hours. Obviously, for such a condition no assistance can be obtained from Fourier analysis, since the value of ϕ_2 would be practically the same, whether the observations were referred to G. M. T. or to local time. Further observations during the May-July period in the Atlantic and Indian oceans would supply valuable data both for determining whether the 12-hour wave observed in the mid-Pacific is local or world-wide in distribution and whether it progresses according to local or universal time.

However, if we assume the existence of both 24-hour and 12-hour waves, the combination, according to local time, of observations from two stations differing in longitude

[a] *Met. Zeit.*, vol. 23 (1906), pp. 115–121, especially, p. 121.
[b] *Met. Zeit.*, vol. 21 (1902), pp. 201–213, especially p. 204.
[c] *Phil. Trans.*, Series A, vol. 206 (1906), pp. 299–334, paragraph 27.
[d] *Meteorological and Magnetical Observations, Flagstaff Observatory*, 1858–1863, Mannheim, 1867, plates 5 and 7 of Appendix.

by 180° should result in the neutralization of universal-time effects and the strengthening of local-time effects, provided, of course, that the same effects occur at both stations and are of approximately equal value at both. Proceeding along this line, a study was made of the data in hand to determine (1) whether the 12-hour wave with an average amplitude of 4 per cent of the mean value (ranging from 2 per cent in December to 8 per cent in June) progresses more nearly according to local or universal time, and (2) whether there is evidence of any other local-time components of world-wide occurrence. For this purpose a separate study was made of the diurnal-variation observations from 24 selected days (12 pairs), the places of observation represented by each pair differing in longitude by approximately 180°. The resulting mean curve of these compensated observations, *according to local time*, was found to be very similar to curve C of Figure 23. (As a matter of fact, the new curves differ very little from curve C of Figure 23, except with respect to the number of observational series which they represent.) While an examination of the 24-day mean curve indicates a possible local-time wave of small amplitude and approximately 6-hour period, it shows no evidence of any other wave of appreciable amplitude. According to Fourier analysis, the 6-hour wave has an amplitude of about 3 per cent of the mean-of-day value, P_m, and its phase-angle at local midnight is zero.

The results just stated, so far as they go, indicate: (1) That the 12-hour wave of the diurnal variation of the potential gradient over the ocean, like the 24-hour wave, is approximately a universal-time phenomenon, as one would indeed be led to infer from the fact that the corresponding phase-angles (ϕ_2 of Table 80) are nearly constant, notwithstanding the relatively large differences in the local times of the stations at which the observations were made; (2) as regards the 6-hour wave, which apparently is the only local-time wave of general occurrence over the oceans, both the amplitude and phase-angle are in as close agreement with the results obtained by Bauer[a] from his analysis of the Ebro potential-gradient data for 1910–1920, and those of Chree[b] based on the Kew data from 1898 to 1912, as one could expect from the limited observational data available for investigation. Whether the results obtained with reference to the 6-hour wave are representative of an actual phenomenon or simply the effect of a fortuitous combination of observations is another question which must await, for answer, the accumulation and study of more observational data. Similarly, the amplitude of the 12-hour wave over the oceans is, in general (except during the May-July quarter), so small that its failure to show up under the method of deriving local-time means from non-simultaneous "compensated observations" does not by any means prove that it occurs over the oceans as a universal-time phenomenon. In fact, owing to the relatively small number of "compensated" series now available, the most important positive result coming from this method of attack is the unmistakable evidence which it furnishes with reference to the progress of the 24-hour wave approximately according to universal rather than local time, and the absence of major local-time effects of general occurrence.

CONFIRMATORY EVIDENCE FROM ISOLATED DAILY OBSERVATIONS.

The diurnal variation of the potential gradient, as given in the foregoing discussion, could, of course, be obtained only from direct observation of the actual variation during a great number of days. However, as stated elsewhere (Atmospheric-Electric Results, Vol. V, p. 197), in addition to the diurnal-variation series, isolated sets of potential-gradient observations are also made daily on the *Carnegie* at about 9 or 10 o'clock ship's time as part of the regular observational program. As in the case of diurnal-variation observations, each daily set is composed of 20 observations made at 1-minute inter-

[a] *Terr. Mag.*, vol. 27 (1922), pp. 1–30, Table 14 and paragraph 40.
[b] *Phil. Trans.*, Series A, vol. 206 (1906), pp. 299–334, paragraph 15, and vol. 215 (1915), pp. 133–159, paragraph 12.

vals. While regular morning observations are perhaps more likely to be made under disturbed conditions than are the 24-hour series of observations, it nevertheless appears from the foregoing evidence regarding a 24-hour wave progressing according to universal time that, if there is a large number of such isolated sets for each hour of the Greenwich day, the resulting series of the mean hourly values, one for each hour of the Greenwich day, should bear a general resemblance to the true diurnal-variation for the time of

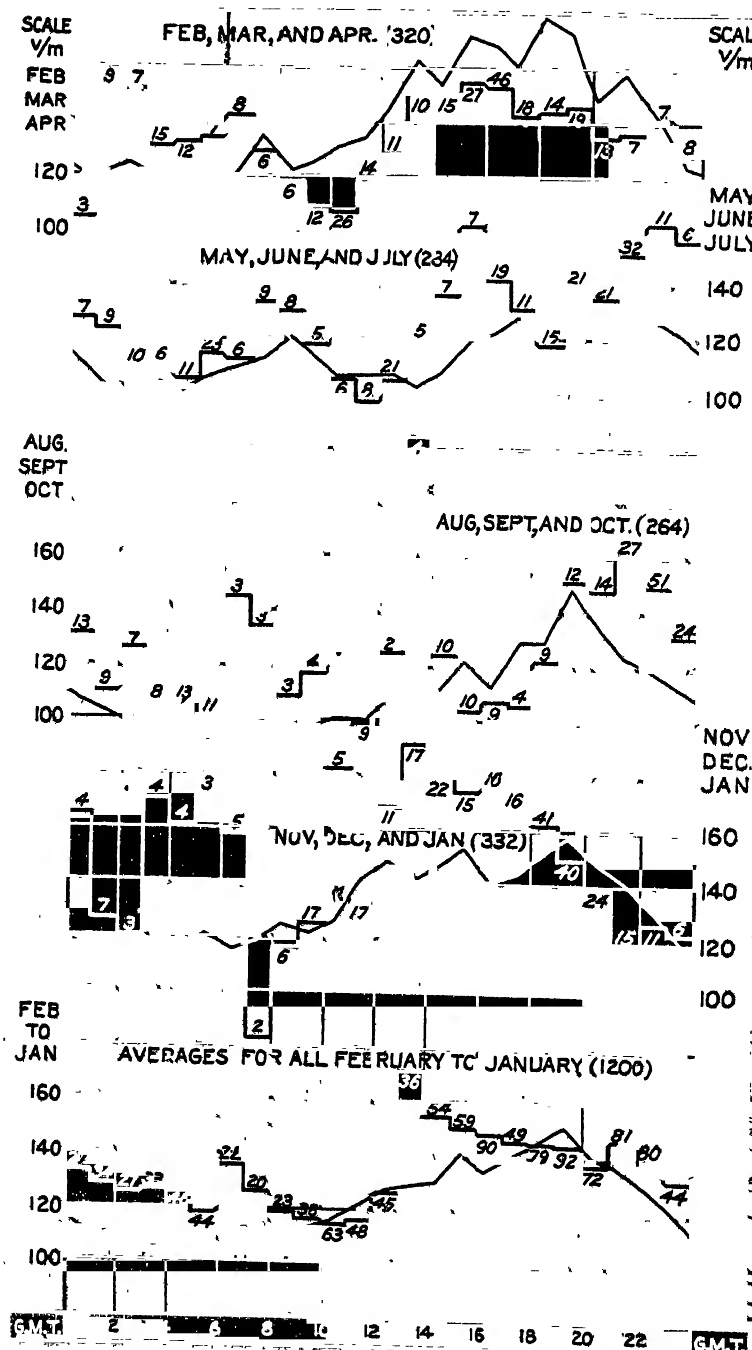

FIG. 27.—Mean Values of Potential Gradient of the Atmosphere observed on the *Carnegie*, 1915–1921; grouped for Greenwich Hours from (*a*) Daily Determinations—Heavy Lines, and (*b*) Diurnal-Variation Series—Light Lines.

year in which the isolated observations are made. There were 1,200 such isolated sets of observations made on about 800 days during cruises IV, V, and VI, in addition to the 59 regular 24-hour series of diurnal-variation observations. Since the *Carnegie* sailed around the globe several times during the three cruises in question, the observations are, for most parts of the year, fairly well distributed throughout the Greenwich day, although the geographical distribution under the circumstances could not be as good as is to be desired. While most of these observations were made as part of the regular daily program of morning observations, many supplementary observations were also made in the latter part of the afternoon and a considerable number of others originally formed parts of incomplete diurnal-variation series which had to be discontinued because of unfavorable weather conditions or instrumental difficulties.

The curves of Figure 27 were prepared to test whether or not there is any similarity between the succession, according to G. M. T., of isolated daylight values and those from consecutive 24-hour series. The heavy angular curve at the top of the figure represents 320 isolated sets of observations made during the February-March-April period, 1915-1921, each observed value being referred, according to the longitude of the ship's position, to the appropriate hour of the Greenwich civil day. The numerals on the heavy curve indicate the number of separate 20-minute sets entering into the respective hourly means. The light curve at the top of the figure is the mean diurnal-variation curve for the same 3-month period as derived from twelve 24-hour series of observations. Similar curves are shown for May-June-July, August-September-October, November-December-January, and for the year (all isolated observations, 1915–1921). The mean data for each year and each 3-month period for the isolated observations are given in Table 82 (see section "Annual Change of Potential Gradient over the Oceans," p. 404).

Bearing in mind that the daily observations are representative of a wider range of meteorological conditions than are the diurnal-variation observations, comparison of each pair of curves in Figure 27 shows a fairly consistent tendency toward similarity. In fact, except where the number of daily observations entering an hourly mean is relatively small, the agreement of the two curves is fair. It should be especially noted that for each of the heavy curves the mean hourly values in the first half of the Greenwich day tend to be lower than those in the second half, and that in both yearly mean curves each hourly mean value between 13^h and 23^h G. M. T. exceeds the highest value between 23^h and 13^h G. M. T.

Although many attempts have been made to formulate the relation between day and night values of the potential gradient, the relations found have applied only to individual stations or limited regions. The fact that no general relation has been found between day and night values is readily understood if it is assumed that the 24-hour wave is approximately in the same phase everywhere, over sea and land, regardless of local or solar time.

It is of interest, also, to note that practically all observations on the *Carnegie* other than the night observations of the 24-hour series of diurnal-variation observations are made during daytime. The qualitative agreement between the two sets of mean curves of Figure 27, one set based practically altogether on daylight observations and the others (the diurnal-variation curves) on approximately equal numbers of daylight and night observations, points to the existence of an important component in the diurnal variation which is primarily a function of universal rather than local time.

ON THE DERIVATION AND VALIDITY OF MEAN-OF-DAY VALUES OF THE POTENTIAL GRADIENT OF THE ATMOSPHERE FROM ISOLATED DAILY OBSERVATIONS.

The potential-gradient observations on the *Carnegie* differ from those customary at fixed observing stations in that the location of the observing station changes from day to day and also because it has not thus far been practicable to obtain continuous records

on the vessel. The regular set of morning observations, occasionally supplemented by one or two additional sets later in the day, serve very well to give the order of magnitude of the gradient over the ocean without the introduction of corrections for diurnal variation. However, when it is desired to study the distribution of the potential gradient, say, with latitude, or over the different oceans, or if information is desired regarding the annual variation and secular changes of the gradient, the data from such isolated observations can not be utilized directly to give reliable results. The occasional 24-hour series of diurnal-variation observations, which were made fortnightly or weekly on the *Carnegie* during her fourth, fifth, and sixth cruises, were initiated and continued with two major purposes in view. The first was to obtain direct information concerning the diurnal variation of the potential gradient over the oceans as a subject of research, and the other was to utilize the knowledge so gained for the more effective reduction and study of the results of the daily observations.

It has already been shown that at least the greater part of the diurnal variation of the potential gradient over the oceans is due to a wave which progresses according to universal rather than local time. Thus observations made at a fixed local time, say 9^h, will fall on successive days on higher or lower parts of the diurnal-variation curve as the vessel occupies positions differing in longitude. From the curves of Figure 24 it is obvious that most forenoon observations in the Pacific will be higher than the mean value for the day, while in the Indian Ocean observations made during the forenoon will tend, in general, to be well below the average value for the day.

Further, from the qualitative agreement of the curves of Figure 27 it is seen that all potential-gradient observations at sea tend to give values which are lower than the mean of day if made in the forenoon of the Greenwich civil day and values higher than the mean of day if made in the afternoon of the Greenwich day.

Thus there are several lines of evidence indicating the need of correcting for diurnal variation the daily potential-gradient observations made on the *Carnegie*, and that such correction must take account of the universal-time component of the diurnal variation.

If the subsidiary diurnal-variation curves of Figure 27, corresponding to the several 3-month periods of the year, are examined, it will be seen that the diurnal variation *expressed as percentages of the mean-of-day value* remained roughly constant over the period 1915 to 1921. Therefore, the mean curves for the respective 3-month periods may be used to correct for diurnal variation all daily observations of 1915 to 1921. By the adoption of this procedure the work of applying the necessary correction-factors was greatly simplified without the introduction, it would appear, of serious error.

It is realized that the potential gradient is frequently subject to large but temporary disturbances and that an isolated observation may sometimes be made during the occurrence of such a disturbance. Again, it is well known that the diurnal variation sometimes for an entire day or even for several days may be entirely different from the mean variation derived from the control observations. In all these cases, obviously, the procedure of applying a correction-factor based on the normal diurnal-variation can not give even an approximately correct mean-of-day value. However, where we are dealing with hundreds of observations, most of which correspond to approximately normal conditions, there can be no doubt that reductions to mean of day by the application of per cent factors based on mean diurnal-variation curves are conducive to a greatly increased general accuracy over what would be obtained from the use of the same observational data without correction for diurnal variation.

ON THE DISTRIBUTION OF POTENTIAL GRADIENT OVER THE OCEANS, ESPECIALLY AS REGARDS VARIATION WITH LATITUDE.

Some observers and writers have concluded that the atmospheric potential-gradient probably increases with latitude, or from the tropical regions toward either pole. However, the available land observations are so much influenced by local conditions that it is difficult, if not impossible, to obtain from them conclusive evidence regarding this point. The *Carnegie* may be better suited than fixed stations for obtaining data regarding variation of the potential gradient with latitude. For example, it is known from observations at sea that the atmospheric-electric elements over the oceans are much less affected by permanent local conditions than at the average land station. There is also a considerable advantage in being able to observe in various oceans and latitudes on the same vessel and with the same apparatus, since differences inherent in the instruments used, in the procedure followed, and in the methods of standardization are here eliminated.

TABLE 81.—*Atmospheric Potential-Gradient Results Obtained on the Carnegie, 1915-1921, Corrected for Diurnal Variation and Grouped for 3-Month and 12-Month Periods for 20-Degree Belts of Latitude.*

Latitude belt	Group values: February, March, and April		May, June, and July		August, September, and October		November, December, and January		February to January: Total No. days	Means: W't'd	Arith.
March 1915 to February 1917 (Approximate Epoch 1916.2) during Cruise IV											
° °	v/m		v/m		v/m		v/m			v/m	v/m
60 N–40 N	...		133	(6)	159	(42)	...		48	155	146
40 N–20 N	137	(7)	124	(14)	138	(17)	155	(8)	46	137	138
20 N– 0 N	126	(23)	132	(32)	119	(18)	128	(15)	88	127	126
0 S–20 S	...		119	(5)	142	(9)	136	(16)	30	135	132
20 S–40 S	146	(4)	116	(8)	131	(12)	138	(27)	51	134	133
40 S–60 S	166	(52)	210	(8)	123	(3)	148	(36)	99	162	162
December 1917 to June 1918 (Approximate Epoch 1918.2) during Cruise V											
40 N–20 N	...		146	(15)	...		...		15	146	146
20 N– 0 N	154	(1)	110	(5)	...		...		6	117	132
0 S–20 S	142	(25)	...		...		...		25	142	142
20 S–40 S	122	(14)	...		...		167	(14)	28	145	144
40 S–60 S	...		...		...		151	(27)	27	151	151
October 1919 to November 1921 (Approximate Epoch 1920.8) during Cruise VI											
40 N–20 N	99	(24)	102	(16)	147	(14)	120	(29)	83	115	117
20 N– 0 N	...		115	(28)	90	(14)	116	(31)	73	111	107
0 S–20 S	102	(8)	105	(25)	104	(12)	110	(22)	67	106	105
20 S–40 S	103	(29)	137	(17)	105	(53)	136	(28)	127	116	120
40 S–60 S	121	(10)	...		112	(8)	143	(12)	30	127	125
Means of all...	131	[1](197)	126	[1](179)	126	[1](202)	135	[1](265)	[1]843	130	133

[1] Difference in number of days from those given in Table 82 (see footnote) is because of inclusion here of 9 observations Oct. 19–29, 1919, 3 observations Nov. 3–6, 1921, and 59 diurnal-variation series, which were omitted from that table.

It is true that a vessel like the *Carnegie* does not, in general, remain long enough in any given locality to establish conclusive local data. However, during the years 1915 to 1921 the *Carnegie* repeatedly visited many different regions, often at different times of year, and thus, by reason of the greater regularity of ocean conditions, it is believed that

reliable information has been obtained regarding the variation of the various atmospheric-electric elements with latitude.

In Table 81 the data from sea observations on 843 days have been arranged to bring out such relations as may exist between latitude and the mean value of the potential gradient. In that table all values other than those from the 59 diurnal-variation series have been reduced approximately to mean of day, as indicated previously (see p. 401). In order to obtain a fairly detailed picture of the distribution with regard to latitude, separate mean values of the potential gradient were formed corresponding to 20-degree belts of latitude, north and south, for each of the 3-month periods February to April, May to July, August to October, and November to January. Separate mean values were formed for cruises IV, V, and VI, partly to secure a greater number of representative mean values than could be gotten from the data for the individual years and partly to have available for comparison similar data obtained by different observers and corresponding to different epochs. Thus the data from Cruise IV (extending over approximately two years) are given separately in Table 81 from those for Cruise V and those for Cruise VI (also extending over two years).

The data from Cruise V are not strictly representative of sea conditions in mid-ocean, since the extent of the cruise was limited to sailing from Buenos Aires southward along the Argentine coast to Cape Horn, then north along the western coast of South America, and after passing through the Panama Canal continuing northward near the eastern coast of North America (see Fig. 4). Further, since this cruise was much shorter than the others, the number of observations was in most cases too small and insufficiently distributed throughout the year to give reliable mean values. The data are, however, included for completeness.

A comparison of the data from cruises IV and VI as given in the last three columns of Table 81 shows that on both cruises the potential gradient, on the average, was lowest in the equatorial regions and increased gradually as higher latitudes were reached, at least up to the parallels of 60° north and 60° south, respectively. Also, despite the fact that some of the quarterly means for the separate latitude-belts do not have sufficient observations to be representative, there is a decided tendency in the respective quarterly means toward an increasing gradient with increase of latitude, similar to but less regular than that shown in the February to January means.

ANNUAL CHANGE OF THE POTENTIAL GRADIENT AS INDICATED BY OCEAN OBSERVATIONS.

It is well known that the annual mean value of the potential gradient of the atmosphere as recorded and measured at land stations is in general not constant over a series of years, but varies considerably from year to year. This change in the annual mean value from year to year will be referred to here as the annual change and should accordingly be distinguished from the annual variation which refers to the characteristic departures of the monthly mean values from the yearly mean. In view of the large annual changes reported from nearly all land stations during the years 1915 to 1921, it is of interest to determine to what extent, if any, the presence of this phenomenon is indicated by the ocean observations. The reduction of all potential-gradient observations made on the *Carnegie* from 1915 to 1921 to the same absolute standard of values now makes it possible, for the first time, to make such an investigation for the oceans, provided the results are properly corrected for diurnal variation.

There are available for this investigation both the mean-of-day values corresponding to 59 diurnal-variation series and the results obtained on 772 additional days from regular morning observations and from incomplete diurnal-variation series discontinued because of development of instrument troubles or poor meteorological conditions. The

results of all observations except the diurnal-variation series have been corrected for diurnal variation in accordance with the method outlined on page 401. Where two or more observations were made on the same day, each is separately corrected for diurnal variation and the mean of several corrected values used as the mean-of-day value.

Since the diurnal variation of the potential gradient is approximately the same (see p. 402) for the 3 months of each quarter, February to April, May to July, August to October, and November to January, the work of applying approximate corrections for diurnal variation was materially reduced by using the same correction-factor curve for all observations made in February to April, May to July, August to October, and November to January, respectively. It is obviously impossible to eliminate all errors arising from a possible annual variation of the potential gradient and from its variation with latitude. However, with the large number of observations now available, it appears desirable to obtain mean values of potential gradient, as corrected for diurnal variation, for each 3-month period during the years 1915 to 1921. The mean values resulting from such a grouping are given in Table 82, together with interpolated values (inclosed in parentheses) for periods in which either no obervations were made, or else the days on which observations were made were so few in number that the corresponding means would not be representative of the period to which they belong. The mean values for each 3-month period, as, for example, February-March-April, show throughout the years beginning with 1915, first an increase to 1916 or 1917 and then a gradual and consistent decrease to the end of 1921. This is so closely in accord with what has been observed at land stations, where reliable or undisturbed data of required extent are available, as to leave no doubt regarding the reality and universality of this phenomenon. The annual changes deduced from the *Carnegie* observations and those observed at various land stations, and their relationship with sunspottedness, are discussed by Doctor Bauer in another part of this volume (pp. 361–381).

That the distribution of observations from which Table 82 was derived was sufficiently general both as to latitude and time of year to justify the conclusion of a marked

TABLE 82.—*Atmospheric Potential Gradient Results Obtained on the Carnegie, 1915–1921, Corrected for Diurnal Variation and Grouped in 3-Month Means and One General Mean.*

Group values														
February, March, and April			May, June, and July			August, September, and October			November, December, and January			General mean February to January		
Approx. epoch	No. days	P_m	Approx. epoch	No. days	P_m	Approx. epoch	No. days	P_m	Approx. epoch	No. days	P_m	Approx. epoch	No. days	P_m
		v/m			v/m			v/m			v/m			v/m
1915.3	29	127	1915.4	33	127	1915.7	65	139	1916.0	34	149	1915.6	161	136
1916.2	33	182	1916.5	36	146	1916.7	29	154	1917.0	59	137	1916.6	157	155
1917.1	20	184	(1917.4)	.....	(141)	(1917.7)	.....	(143)	1918.0	39	156	1917.6	59	144
1918.2	37	132	1918.4	20	137	(1918.7)	.....	(132)	(1919.0)	.....	(144)	1918.6	57	136
(1919.2)	.....	(120)	(1919.4)	.....	(128)	(1919.8)	[1]	(121)	1920.0	67	138	1919.6	67	126
1920.2	44	108	1920.5	41	120	1920.7	27	110	1921.0	45	110	1920.6	157	112
1921.2	22	100	1921.4	37	109	1921.7	55	104	(1922.0)	[1]	(101)	1921.4	114	104
Means: 1918.2	185	129	1918.4	167	130	1918.7	176	130	1919.0	244	138	1918.6	772	130

[1] Values given in parentheses are interpolated values because either (*a*) no observations were made for the periods concerned or (*b*) observations were so few in number and on so few days as not to justify the means being used. Thus, during August to October 1919 the only observations were on 9 days, October 19 to 29, with $P_m = 151$ v/m; during November 3 to 6, 1921, at the end of Cruise VI, 3 days' observations gave $P_m = 151$ v/m. Some observations given in the Table of Atmospheric-Electric Results, Volume V, were omitted in preparing this table because of poor meteorological conditions, as follows: April 27 (p. m.), 1915; July 4, 8, 1916; March 30, 1918; October 25 (9^h1 and 9^h2) and 29 (8^h4 to 8^h5), 1915; January 4, 1916, and September 20, 1916.

change from 1915 to 1921 may be seen by a reference to Table 83, which is a summary of certain data from Table 82.

TABLE 83.—*Comparison of Mean Values of the Potential Gradient as Observed Aboard the Carnegie in Various Latitudes on Cruises IV and VI.*

Lat. belt	Potential gradient				
	No. days	Mean epoch 1916.2	No. days	Mean epoch 1920.8	Decrease
° °		v/m		v/m	v/m
40 N-20 N	46	137	83	115	22
20 N- 0 N	88	127	73	111	16
0 S-20 S	30	135	67	106	29
20 S-40 S	51	134	127	116	18
40 S-60 S	99	162	30	127	35
Average decrease in atmospheric potential-gradient during 4.6 years....					24

Here we have compared for each 20-degree belt of latitude from 40° north to 60° south the mean yearly values of the potential gradient during Cruise IV (mean epoch 1916.2) and during Cruise VI (mean epoch 1920.8). It is seen that in all latitudes for which there were sufficient observations for such a comparison the mean values observed on Cruise VI were from 15 to 20 per cent lower than those observed on Cruise IV. Owing to the possible combined effect of sunspot and other variations (see reference to discussion, p. 405), it would not be safe to infer a linear annual change between the two epochs 1916.2 and 1920.8 from the above observed change.

By taking account of the annual change which has been shown to exist for the atmospheric potential-gradient over the ocean and of the changes in absolute value of the gradient with latitude, it is now possible to get an approximate measure of the average potential-gradient over several of the large oceans. The data from cruises IV and VI are well suited for such comparisons, since during each of these the *Carnegie* not only circumnavigated the globe but also spent much time in both northern and southern latitudes. Since, as already stated, the course of Cruise V was not such as to provide representative mid-ocean data for either the Atlantic or the Pacific, the results from that cruise are not considered in this connection.

The results show that, with a satisfactory distribution of observations, the mean potential gradient in the North Pacific was 136 volts per meter during Cruise IV and 97 volts per meter during Cruise VI; similarly, the respective mean values for the South Pacific were 142 volts per meter and 107 volts per meter. While these data again show the effect of the annual change between 1915 and 1921 on the gradient, we may not, without further evidence, conclude that the potential gradient is regularly higher over the South Pacific than over the North Pacific. For we have just seen that the gradient increases with latitude, and since the *Carnegie* spent much more time in high southern latitudes during the fourth cruise than in corresponding northern latitudes, it is quite probable that this will satisfactorily account for the difference between the mean values in the North and South Pacific on Cruise IV. Similarly, the difference between North and South Pacific values during Cruise VI is probably accounted for by the fact that considerably higher latitudes were reached in the South Pacific than in the North Pacific on this cruise.

In the Atlantic Ocean the mean values were 156 volts per meter and 130 volts per meter, and in the Indian Ocean 185 volts per meter and 117 volts per meter for cruises IV and VI, respectively. While the effect of the annual changes between 1915 and 1921

is again plainly evident both in the Atlantic and the Indian oceans as shown by the results for the two cruises, the unusually high values found during Cruise IV are without doubt largely and perhaps wholly attributable to the fact that in both oceans practically all observations obtained on Cruise IV were made during the *Carnegie's* circumpolar cruise, which lay almost entirely between latitudes 50° south and 60° south. This, as we have seen from the variation of potential gradient with latitude, would lead one to expect conditions similar to those actually observed.

Thus, after allowing approximately for annual change and for latitude effect, there was no indication of any marked difference in the atmospheric potential-gradient over the several oceans for the same time of year and the same latitude belt.

VARIATIONS AND DISTRIBUTION OF IONIC CONTENT, CONDUCTIVITY, AND AIR-EARTH CURRENT-DENSITY OVER THE OCEANS.

DIURNAL VARIATIONS.

During 1915 to 1921 daily observations were regularly made on the *Carnegie*, when the vessel was at sea, of the ionic content for both positive and negative ions, n_+ and n_-, and of the unipolar conductivities, λ_+ and λ_-. Occasional series of diurnal-variation observations of n_+ were made also during these years. Diurnal-variation observations of the positive conductivity were made from 1918 to 1921 and of both λ_+ and λ_- from April to November 1921.

There were 54 diurnal-variation series for n_+ and their general distribution was as follows: During cruises IV and V, 9 series in the North Pacific Ocean and 14 in the South Pacific Ocean; during Cruise VI, 8 in the North Pacific Ocean and 9 in the South Pacific Ocean; during cruises IV and VI combined there were 8 series in the Indian Ocean and 6 in the Atlantic Ocean. The mean diurnal-variation graphs corresponding to the above groupings are given in Figure 28, all observations being referred to local mean time. Inspection of these graphs shows several well-marked characteristics that are common both for observations from widely separated regions and those made in the same regions but on different cruises. The most marked common feature of these graphs is a principal minimum at about 3^h to 5^h local mean time, followed by a sharp rise to the chief daily maximum occurring in general at about 8^h. (Only the mean curve for the North Pacific Ocean from observations on Cruise VI has its chief maximum during the night, although the mean curve from similar observations during Cruise IV in the same region is in good general agreement with the curves from other regions.) Most of the curves also indicate the occurrence of a secondary minimum shortly before noon, after which the values reach a flat secondary maximum which persists with slowly decreasing values throughout the afternoon and which gives way, shortly before midnight, to a relatively rapid return to the chief morning minimum. Only in the curve for the Atlantic Ocean is there a suggestion that the mid-day minimum may be the chief one of the day. However, the number of series entering into this curve is very small, only six days, and as the atmospheric-electric conditions were considerably disturbed on several of these days it is believed that the average variation in the Atlantic Ocean on normal days may not differ much from the mean variation found in the other oceans. From the foregoing it appears one is warranted in expecting the ionic numbers over the ocean to be, in general, above the average value during the day and below the average during the night, with the chief minimum occurring at about 4^h and the chief maximum at about 8^h local mean time, the tendency being towards approximately constant or slowly decreasing values during the afternoon.

Observations of the diurnal variation of the positive conductivity on the *Carnegie* during 1918 to 1921 have provided 34 usable series, and of these the last 14 made were accompanied by similar observations for the negative conductivity. Thus it is possible

to determine in a general way the characteristic features of the diurnal variations not only of the two unipolar conductivities and of the total conductivity, but also those of the air-earth current-density, since potential-gradient measurements regularly accompanied those for the conductivity.

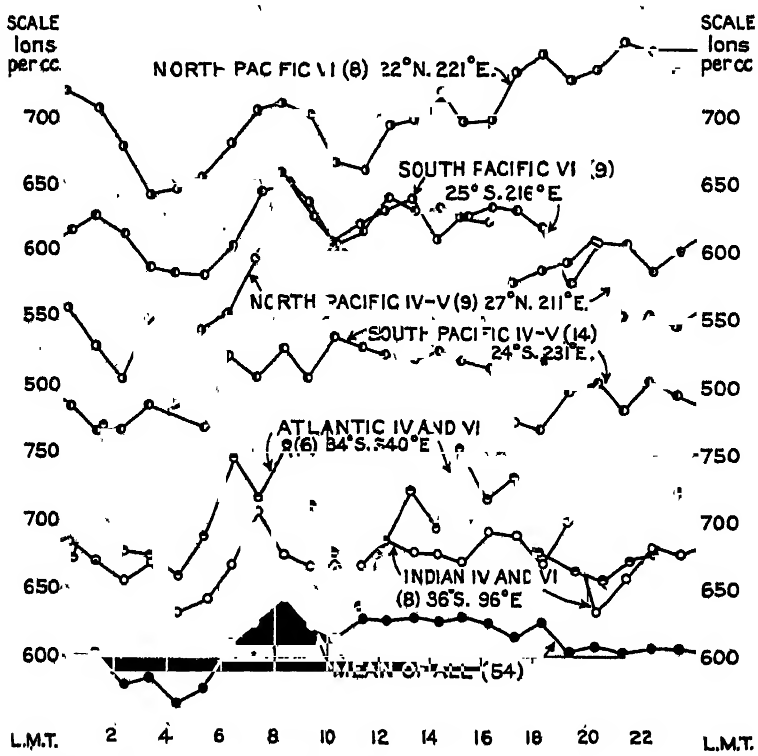

FIG. 28.—Diurnal Variation of Positive-Ion Content of the Atmosphere from Observations on the *Carnegie*, 1915–1921.

From the results of several land stations where conductivity records have been obtained, it is evident that the diurnal variation of the positive and negative conductivities at a given time and place are in general very similar, and this has been found to hold also for the oceans. However, at some stations, as, for example, at Potsdam, the nature of the diurnal variation varies greatly with the time of year, and in general is different for a given time of year than at other stations. From the data before us it is evident that over the oceans, as over land, the diurnal variation in a given region apparently depends to quite an extent also upon the time of year and for a given time of year upon the latitude. Apparently, then, there can be no such thing as a simple and general expression for the diurnal variation of the conductivity. It is not possible from the data in hand to derive reliable diurnal-variation curves for various regions and times of year suitable for approximately reducing to mean of day observations taken on a moving vessel.

During the months April to October 1921, fourteen 24-hour series of simultaneous diurnal-variation observations for positive and negative conductivity, λ_+ and λ_-, and potential gradient were obtained. The extreme latitudes represented by these observations were about 29° south and 34° north, and, with the exception of one series in the Caribbean Sea, all were obtained in the Pacific Ocean. Half the observations were made within 15° of the equator, average latitude 8°, and the remainder near the tropics, with an average latitude of 26°.

As found for λ_+ from earlier observations on the *Carnegie*, the diurnal variation for both λ_+ and λ_- is less pronounced than that of the potential gradient and progresses according to local mean time. Separate mean curves representing the region of the tropics and of the equator, however, indicate some interesting differences. Although both curves show maxima in the neighborhood of 8^h to 10^h and 20^h to 22^h, the intervening minimum appears from these observations to be decidedly secondary for the region of the tropics, while it is the principal minimum for the region of the equator. The mean values, expressed in units of 10^{-4} E. S. U., are as follows: For the region of the tropics, $\lambda_+=1.60$ and $\lambda_-=1.39$, and for the region of the equator, $\lambda_+=1.58$ and $\lambda_-=1.34$.

In general, it may be stated that the diurnal variation of the conductivity tends to be somewhat similar to, though less regular than, that of the ionic content, and that the daily ranges of the mean curves run from 10 to 20 per cent of their respective mean values according to place and time of year.

The regular forenoon schedule of observations at sea on the *Carnegie* during 1915 to 1921 included the measurement, as nearly simultaneously as possible, of both the unipolar conductivities and the potential gradient. Thus there are available from these observations a large number of isolated determinations of the air-earth current-density. Now, earlier observations, as indicated on page 356 of the "Annual Report of the Director of the Department of Terrestrial Magnetism for 1921," had shown that the diurnal variation of positive air-earth current-density (i_+), the product of the potential gradient and the positive conductivity, resembled that of the potential gradient much more closely than it did that of λ_+. Accordingly, when it became apparent that the diurnal variation of the conductivity was too irregular to afford a basis for even an approximate reduction of the observed current-densities to mean-of-day values, special 24-hour series of simultaneous measurements of both conductivities and of the potential gradient were undertaken to determine directly the diurnal variation of the current-density.

The results of 14 such series of observations show (1) that the diurnal variation of the total current-density differed but little from that of each of its unipolar components; (2) that when observations from regions extending over a considerable range of longitude were grouped to form a mean curve the range of the mean curve was invariably greater when the observations were referred to a common time-scale than when each series was referred to its own local mean time; and (3) that the mean curves for the separate oceans show similarity only when all observations are referred to a common time-scale.

In Figure 29 are reproduced in order the following mean diurnal-variation curves from the results obtained during 1918 to 1921 for the total current-density, $I=P(\lambda_++\lambda_-)$, and the unipolar current-densities i_+ and i_-, all observations being referred to Greenwich mean time:

- A_{i+}, positive current-density from 5 series in the Pacific Ocean during February, March, and April;
- B_I, B_{i+}, and B_{i-}, total current-density and its positive and negative components, respectively, from 8 series in the Pacific Ocean during April (1 day), May, June, and July;
- C_I, C_{i+}, and C_{i-}, total current-density and unipolar components from 6 series in the Pacific Ocean during August, September, and October;
- D_{i+}, positive current-density from 6 series in the Pacific Ocean during November, December, and January;
- E_{i+}, positive current-density from 4 series in the Indian Ocean during June, August, and October;
- F_{i+}, positive current-density from 3 series in the Atlantic Ocean during December, March, and April.

A comparison of the curves B_{i+} and B_{i-} with curve B_I and of the curves C_{i+} and C_{i-} with C_I show that for a given time of day the percentages of their respective mean-

of-day values taken from the component curves are practically the same as those obtained from the total current-density curves. Accordingly, so long as we are dealing only with percentages or ratios in the reductions to mean of day, we may for practical purposes utilize the earlier curves for i_+ for which the corresponding values of i_- were obtained, just as we do the I-curves.

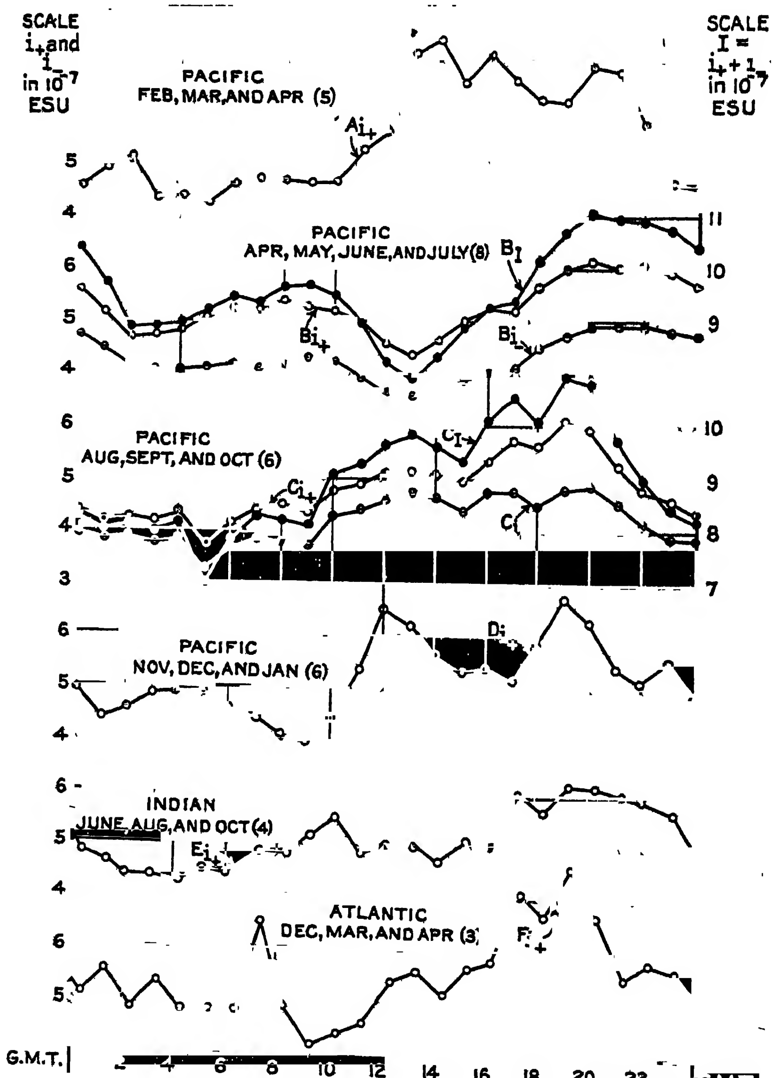

FIG. 29.—Diurnal Variation of the Air-Earth Current-Density from Observations on the *Carnegie*, 1918–1921.

Comparison of the curves E_{i+} and F_{i-} with the potential-gradient curves of the Indian and Atlantic oceans (Fig. 24) shows a fair general agreement between the two kinds of curves, even with curves based on a very small number of series. It is only for the Pacific Ocean that there are a sufficient number of series available to form mean curves for I or i_+ for each 3-month period of the year, as was done in Figure 26 for the potential gradient. However, comparison of the respective curves of Figures 26 and 29 shows that changes in the diurnal variation which take place during the course of a year are practically the same for the current-density as for the potential gradient. Comparison of curves E_{i+} with the curves for the corresponding months for the Pacific Ocean

shows the resemblance to be closest with the curves of the C group, but also a tendency to favor the B group. Since the series entering into curve E_{i+} for the Indian Ocean were obtained in June, August, and October, this is what one would expect and indicates that the diurnal variation of the current-density may be the same in different oceans for the same time of year. Similar evidence comes from a comparison of the curve F_{i+} for the Atlantic Ocean for the months December, March, and April, and the curves A_{i+} and D_{i+} for the Pacific Ocean, which contain the results for December, March, and April.

Thus the evidence available at this time indicates that over the oceans the diurnal variation of the air-earth current-density is similar to that of the potential gradient (1) as to the general nature of the variation throughout the day, (2) as to its progression according to universal rather than local mean time, and (3) as to the changes in its characteristic features with time of year.

CHANGE WITH LATITUDE AND CHANGE FROM EPOCH 1916 TO EPOCH 1921.

While detailed information regarding the atmospheric-electric elements for a given location can not be obtained accurately from the results of the observations on the *Carnegie*, it is believed, for reasons already stated (p. 403), that these observations can be utilized to furnish facts of interest and theoretical value regarding the general distribution of atmospheric electricity over the Earth, especially as regards changes with latitude and as regards evidence of any changes in the absolute values of the elements

TABLE 84.—*Positive and Negative Ionic-Content of the Atmosphere from Observations on the Carnegie during Cruises IV and VI, Giving 3-Month and 12-Month Means for 20-Degree Belts of Latitude.*

Latitude belt.	Group values: February, March, and April				May, June, and July				August, September, and October				November, December, and January				February to January: Total No. days		Means: Weighted		Arithmetic	
	n_+		n_-		n_+		n_-		n_+		n_-		n_+		n_-		n_+	n_-	n_+	n_-	n_+	n_-
MARCH 1915 TO FEBRUARY 1917 (APPROXIMATE EPOCH 1916.2) DURING CRUISE IV																						
° °	ions/cc				ions/cc				ions/cc				ions/cc						ions/cc		ions/cc	
60 N-40 N	......		......		661	(6)	499	(5)	601	(30)	448	(29)	......		......		36	34	611	456	631	474
40 N-20 N	279	(5)	339	(4)	541	(13)	490	(13)	582	(14)	465	(14)	760	(5)	512	(5)	37	36	551	472	541	452
20 N- 0 N	540	(23)	434	(25)	605	(30)	550	(28)	644	(17)	538	(18)	471	(8)	411	(9)	78	80	581	495	565	483
0 S-20 S	......		......		546	(3)	399	(4)	527	(8)	434	(8)	502	(15)	344	(14)	26	26	515	380	525	392
20 S-40 S	617	(5)	522	(6)	642	(5)	432	(5)	622	(11)	508	(12)	563	(19)	408	(19)	40	42	596	456	611	468
40 S-60 S	686	(42)	509	(41)	416	(2)	242	(2)	735	(3)	652	(3)	551	(32)	457	(34)	79	80	600	486	584	465
OCTOBER 1919 TO NOVEMBER 1921 (APPROXIMATE EPOCH 1920.8) DURING CRUISE VI																						
° °	ions/cc				ions/cc				ions/cc				ions/cc						ions/cc		ions/cc	
40 N-20 N	670	(19)	610	(18)	730	(14)	582	(13)	545	(15)	432	(15)	682	(21)	558	(21)	69	67	659	548	657	54[illegible]
20 N- 0 N	......		......		644	(26)	515	(24)	689	(8)	537	(8)	421	(28)	363	(26)	62	58	549	450	585	47[illegible]
0 S-20 S	793	(9)	682	(9)	662	(25)	512	(19)	764	(18)	618	(16)	551	(23)	451	(23)	75	67	668	539	692	56[illegible]
20 S-40 S	654	(24)	548	(24)	738	(17)	618	(16)	745	(43)	611	(49)	578	(26)	444	(25)	110	105	685	558	679	55[illegible]
40 S-60 S	541	(9)	455	(9)	......		......		741	(8)	597	(9)	494	(8)	346	(7)	25	25	590	476	592	46[illegible]
GENERAL MEANS																						
	ions/cc				ions/cc				ions/cc				ions/cc						ions/cc		ions/cc	
Cruise IV	581	(75)	476	(76)	590	(59)	500	(57)	607	(83)	485	(84)	550	(79)	424	(81)	296	298	584	470	576	45[illegible]
Cruise VI	663	(61)	573	(60)	684	(82)	549	(72)	711	(92)	574	(88)	545	(106)	442	(102)	341	322	644	526	641	52[illegible]
Cruises IV and VI	618	(136)	519	(136)	645	(141)	527	(129)	662	(175)	530	(172)	547	(185)	434	(183)	637	620	615	499	608	48[illegible]

as determined by the comparison of the mean results of similar observations on cruises separated by a period of years.

Ionic-content measurements for both n_+ and n_- were regularly made on the *Carnegie* in the forenoon. During the fourth cruise determinations of n_+ and n_- were made on 296 and 298 days, and during the sixth cruise on 341 and 322 days, respectively. The great majority of these observations were made between 9^h and 10^h and nearly all the remaining ones between 10^h and 11^h. From the diurnal-variation curves of Figure 28 we see that, on the average, between 9^h and 11^h the ionic content approximates closely the mean-of-day value. Therefore we may consider the results of the daily observations for ionic content as fair approximations to the respective mean-of-day values, and employ them directly in the formation of mean values for different regions and epochs.

Table 84 gives for cruises IV and VI separate mean values for each of the 3-month periods February to April, May to July, August to October, and November to January for 20-degree belts of latitude from the equator to 60° north and 60° south, respectively. Figures in parentheses indicate the number of days upon which the values given depend. Comparisons among the various mean values disclose no certain tendencies toward a relation between ionic content and latitude, nor is there convincing evidence of a variation with time of year. It may be noted, however, that the 3-month means for all latitudes from cruises IV and VI show for both n_+ and n_- a maximum during the August to October quarter and a minimum for the November to January quarter.

However, if we compare the mean values of n_+ or n_- for the two cruises, we see evidence of an appreciable increase in the values for Cruise VI over that of Cruise IV. For n_+ the respective weighted mean values are 584 and 644 ions per cubic centimeter, or an increase of 10 per cent; and for n_- the respective mean values are 470 and 526 ions per cubic centimeter, an increase of 12 per cent. The mean results from the diurnal-variation series of n_+ during Cruise VI also indicate an increase of the order of about 15 per cent over the corresponding value for Cruise IV.

TABLE 85.—*Comparisons of Ionic-Content Results from Cruises IV and VI Based on Table 84.*

Latitude belt	$(n_+ - n_-)$ for Cruise		Differences (Cruise VI−Cruise IV)	
	IV	VI	Δn_+	Δn_-
° °	*ions/cc*	*ions/cc*	*ions/cc*	*ions/cc*
60 N–40 N	155	....	....	....
40 N–20 N	79	111	108	76
20 N– 0 N	86	99	− 32	− 45
0 S–20 S	135	129	153	159
20 S–40 S	140	127	89	102
40 S–60 S	114	114	− 10	− 10
Means....	118	116	62	56

Table 85 summarizes several comparisons of the ionic-content results of cruises IV and VI based on weighted means given in Table 84. For example, the second and third columns of Table 85 give for cruises IV and VI, respectively, the excess of positive over negative ions per cubic centimeter, and show that the average volume-charge of the air near the surface of the sea was practically the same during cruises IV and VI, whereas the measured content of ions of each kind was, on the average, 10 to 15 per cent greater for Cruise VI than for Cruise IV. It is of interest to note also that the ratio $\frac{n_+}{n_-}$ as com-

puted from the respective values of n_+ and n_- was 1.24 for Cruise IV and 1.22 for Cruise VI. The fourth column of Table 85 gives for each belt of latitude the excess of the weighted mean n_+ from the observations of Cruise VI over the corresponding quantity from Cruise IV; the last column gives similar results for n_-. Whether decreases actually occurred in two of the belts during the time in which the remaining belts showed increased values can not be ascertained. However, it seems more reasonable to suppose that the results found may be the consequences of an undetermined annual variation in the measured quantities.

It has already been stated that observations were made daily on the *Carnegie* of the elements required for the determination of the air-earth current-density. In general, these observations were made between 9^h and 10^h in the forenoon, with the procedure so arranged that the mean times of the potential-gradient observations coincided with that of the conductivity observations. These times usually agreed very closely, although sometimes such agreement was prevented by meteorological or instrumental conditions. However, as seen in the Table of Final Results (pp. 212–265), no computation of the current-density was made where the difference between the mean times of potential-gradient and conductivity observations exceeded 0.5 hour.

It has also been shown (see Fig. 29) that the diurnal variation of the current-density over the oceans is similar to that of the potential gradient and that, as for the potential gradient, reductions of observations from widely scattered stations to approximate mean-of-day values can best be made on the basis of a diurnal variation progressing according to universal time.

There were 525 days during the years 1915 to 1921 on which usable current-density data were obtained. These results have all been corrected for diurnal variation on the basis of per cent corrections obtained by smoothing the curves of Figure 29. Table 86 gives the mean values of the air-earth current-density, so corrected, from 257 observations from Cruise IV, 86 observations from Cruise V, and 182 observations from Cruise VI. The table gives, for each cruise, 3-month means for each 10-degree belt of latitude from the equator to 60° north and to 60° south. As stated in the discussion of the potential-gradient data (p. 404), the data from Cruise V, on account of the brevity of the cruise and the nearness of the course to continental shores, are not truly representative of the mid-ocean conditions. Therefore, the main comparisons and conclusions in regard to the current-density will be based on the data from cruises IV and VI only, since each of these cruises extended over approximately two years and covered the greater parts of the major oceans.

The numbers of observations entering into the 3-month means for the respective latitude-belts are inclosed in parentheses. While the distribution of the observations is inadequate so far as the higher latitudes are concerned, it appears that the table gives no evidence of a well-established difference between the current-densities as observed in different latitudes. To be sure, the values for Cruise VI give a general impression of lower values in the equatorial and high latitudes than in the intermediate regions. However, if one leaves the insufficient data of Cruise V out of account, one of the most striking results appears to be the indication of a general constancy of the current-density at a given time over the regions for which the data apply.

Table 87 consists of a summary of the more important features of Table 86. Because of the scarcity of data for latitudes above 40°, general comparison may only be made for the regions between the equator and latitudes 40° north and 40° south, respectively. From the summarized data of Table 87 for these regions it appears that during both cruises IV and VI the average current-density from the equator to latitude 40° south was of the order of 10 per cent greater than for the corresponding belt north of the equator. Such a preponderance of the values for the Southern Hemisphere was, however, not indicated either for the ionic content or the potential gradient.

TABLE 86.—*Air-Earth Current-Density from Observations on the Carnegie, 1915–1921, Corrected for Diurnal Variation, Giving 3-Month Means for 10-Degree Belts of Latitude.*

Latitude belt	February, March, April	May, June, July	August, September, October	November, December, January	February to January: Total No. results	February to January: Means Wtd.	February to January: Means Arith.
MARCH 1915 TO FEBRUARY 1917 (APPROXIMATE EPOCH 1916.2) DURING CRUISE IV							
° °	$ESU \times 10^{-7}$	$ESU \times 10^{-7}$	$ESU \times 10^{-7}$	$ESU \times 10^{-7}$		$ESU \times 10^{-7}$	
60 N–50 N	....	8.0 (1)	13.3 (7)	....	8	12.6	10.6
50 N–40 N	....	9.2 (4)	8.9 (13)	....	17	9.0	9.0
40 N–30 N	....	9.0 (5)	13.0 (7)	13.4 (2)	14	11.6	11.8
30 N–20 N	3.3 (1)	8.3 (7)	12.9 (5)	15.1 (2)	15	10.4	9.9
20 N–10 N	4.1 (5)	11.6 (16)	10.9 (7)	8.9 (2)	30	10.0	8.9
10 N– 0 N	9.3 (18)	11.5 (6)	10.6 (11)	11.4 (4)	39	10.2	10.7
0 S–10 S	....	10.2 (1)	10.0 (2)	11.2 (4)	7	10.7	10.5
10 S–20 S	....	12.9 (1)	12.1 (5)	11.6 (9)	15	11.9	12.2
20 S–30 S	....	13.2 (4)	9.5 (5)	12.7 (10)	19	12.0	11.8
30 S–40 S	11.6 (6)	10.9 (4)	11.1 (5)	11.2 (9)	24	11.2	11.2
40 S–50 S	12.6 (20)	6.7 (1)	8.8 (3)	9.9 (3)	27	11.7	9.5
50 S–60 S	12.7 (16)	....	....	9.7 (26)	42	10.8	11.2
DECEMBER 1917 TO JUNE 1918 (APPROXIMATE EPOCH 1918.2) DURING CRUISE V							
° °	$ESU \times 10^{-7}$	$ESU \times 10^{-7}$	$ESU \times 10^{-7}$	$ESU \times 10^{-7}$		$ESU \times 10^{-7}$	
40 N–30 N	....	7.7 (6)	....	....	6	7.7	7.7
30 N–20 N	....	8.8 (6)	....	....	6	8.8	8.8
20 N–10 N	....	12.2 (6)	....	....	6	12.2	12.2
10 N– 0 N	7.2 (3)	....	....	....	3	7.2	7.2
0 S–10 S	11.0 (7)	....	....	....	7	11.0	11.0
10 S–20 S	11.9 (11)	....	....	....	11	11.9	11.9
20 S–30 S	7.6 (6)	....	....	11.1 (2)	8	8.5	9.4
30 S–40 S	9.3 (8)	....	....	15.2 (8)	16	12.2	12.2
40 S–50 S	....	....	....	11.2 (9)	9	11.2	11.2
50 S–60 S	....	....	....	11.3 (14)	14	11.3	11.3
NOVEMBER 1919 TO OCTOBER 1921 (APPROXIMATE EPOCH 1920.8) DURING CRUISE VI							
° °	$ESU \times 10^{-7}$	$ESU \times 10^{-7}$	$ESU \times 10^{-7}$	$ESU \times 10^{-7}$		$ESU \times 10^{-7}$	
40 N–30 N	11.3 (3)	10.5 (8)	....	9.9 (1)	12	10.6	10.6
30 N–20 N	8.6 (5)	8.7 (4)	9.8 (1)	6.6 (1)	11	8.6	8.4
20 N–10 N	....	10.4 (6)	9.3 (3)	7.7 (1)	10	9.8	9.1
10 N– 0 N	....	7.9 (10)	7.9 (3)	6.2 (10)	23	7.2	7.3
0 S–10 S	....	9.1 (4)	9.6 (5)	9.0 (7)	16	9.2	9.2
10 S–20 S	9.8 (8)	9.2 (8)	11.4 (4)	8.6 (7)	27	9.5	9.8
20 S–30 S	8.1 (6)	10.0 (2)	10.9 (18)	9.7 (7)	33	10.1	9.7
30 S–40 S	10.3 (15)	15.5 (9)	10.4 (8)	8.4 (7)	39	11.2	11.2
40 S–50 S	6.4 (6)	....	11.1 (3)	7.9 (2)	11	8.0	8.5

As regards the comparison of values obtained on Cruise VI with corresponding data from Cruise IV, the weighted means in the column for February to January show that in none of the latitude-belts either north or south did the value for Cruise VI exceed that for Cruise IV. In fact, in all cases but one, the values for Cruise IV are appreciably larger. If we again use the summarized data from Table 87, we find that the mean current-density for the belt between the equator and the parallel of 40° north was 16 per cent smaller during Cruise VI than during Cruise IV. Similarly, for the region 0° to 40° south the mean value for Cruise VI is 17 per cent less than for Cruise IV.

From the above it is seen that during the years 1916 and 1917 the average air-earth current-density from observations on the *Carnegie* in all oceans was about 11×10^{-7} E. S. U., and that there was little variation from the mean value in the various oceans and lati-

tudes. There is also strong evidence of an actual decrease of the order of 15 per cent in the density of the air-earth current over the oceans between the mean epochs corresponding to cruises IV and VI (approximately 1916.2 and 1920.8).

TABLE 87.—*Summary of Air-Earth Current-Density Results as Given in Table 86.*

Latitude belt	Mean values at approximate epoch								
	1916.2			1918.2			1920.8		
	No. results	Means Wtd.	Means Arith.	No. results	Means Wtd.	Means Arith.	No. results	Means Wtd.	Means Arith.
° °		$ESU \times 10^{-7}$			$ESU \times 10^{-7}$			$ESU \times 10^{-7}$	
60 N- 0 N	123	10.3	10.2	......	......	......	......	......	......
40 N- 0 N	98	10.4	10.3	21	9.2	9.0	56	8.7	8.8
0 S-40 S	65	11.5	11.4	42	11.2	11.1	115	10.2	10.0
0 S-50 S	......	......	......	......	......	......	126	10.0	9.7
0 S-60 S	134	11.3	11.1	65	11.2	11.2	......	......	......

Direct measurements of the ionic mobilities, k_+ and k_-, were not made on the *Carnegie*, but the mobilities have been determined from the simultaneous observations for ionic content and conductivity. While this is not a method of high accuracy, the results obtained are interesting, (1) as giving approximate information concerning the mobilities under sea conditions and (2) as a check to indicate the general correctness of the procedure and the accuracy of the instrumental constants for the conductivity apparatus and the ion counter.

The mobilities computed from 542 practically simultaneous sets of conductivity and ionic-content observations of both signs are summarized in Table 88. The mean values for k_+ and k_- for cruises IV, V, and VI are 1.50 and 1.56, 2.02 and 2.10, and 1.54 and 1.64, respectively, all being expressed in centimeters per second for a field gradient of 1 volt per centimeter. The mean values for cruises IV and VI are in fair agreement with the results from laboratory experiments at room temperatures. Separate mean values are given in the table for each 20-degree latitude belt from the equator to 60° north and 60° south for the first and second halves of cruises IV and VI, and for Cruise V, each of these groups, except that of Cruise V, comprising observations extending over an entire year.

TABLE 88.—*Summary of Ionic Mobilities[1] Determined on the Carnegie, 1915-1921.*

Cruise	Period	Means for latitude belt: 60° N-40° N			40° N-20° N			20° N-0° N			0° S-20° S			20° S-40° S			40° S-60° S			Means of all		
		No. res.	k_+	k_-	No. res.	k_+	k_-	No. res.	k_+	k_-	No. res.	k_+	k_-	No. res.	k_+	k_-	No. res.	k_+	k_-	No. res.	k_+	k_-
IV	Mar 1915 to Feb 1916	16	1.34	1.50	28	1.55	1.41	64	1.38	1.39	8	1.49	1.60	18	1.33	1.39	45	1.36	1.35	179	1.40	1.4
IV	Mar 1916 to Feb 1917	11	1.00	0.97	10	1.40	1.77	18	1.86	2.05	17	2.02	2.30	25	1.83	2.05	24	1.54	1.57	105	1.67	1.8
V	Dec 1917 to June 1918	....	......	......	11	2.09	2.24	8	2.28	2.50	18	2.47	2.43	24	1.84	1.82	17	1.61	1.85	78	2.02	2.1
VI	Nov 1919 to Nov 1920	....	......	......	....	......	......	29	1.55	1.67	37	1.51	1.60	65	1.48	1.56	23	1.38	1.46	154	1.49	1.5
VI	Dec 1920 to Nov 1921	....	......	......	43	1.52	1.59	22	1.74	1.86	31	1.62	1.78	38	1.61	1.70	....	......	......	134	1.60	1.7
	Weighted means, IV	27	1.20	1.28	38	1.51	1.50	82	1.49	1.53	25	1.85	2.08	43	1.62	1.77	69	1.42	1.43	284	1.50	1.5
	Weighted means, VI	....	......	......	43	1.52	1.59	51	1.63	1.75	68	1.56	1.68	103	1.53	1.61	23	1.38	1.46	288	1.54	1.6
	Weighted means, IV and VI	27	1.20	1.28	81	1.52	1.55	133	1.54	1.62	93	1.64	1.79	146	1.56	1.66	92	1.41	1.43	572	1.52	1.6
	Weighted means, all	27	1.20	1.28	92	1.58	1.63	141	1.58	1.67	111	1.77	1.89	170	1.59	1.68	109	1.44	1.50	650	1.58	1.6

[1] Expressed in centimeters per second for a field gradient of 1 volt per centimeter.

Only the data for the second half of Cruise IV and those for Cruise V give any indication of systematic variations of both mobilities with latitude and of values differing materially from the results of laboratory experiments at room temperature. However, for both these groups the *Carnegie* visited equatorial and high-latitude regions with air-temperatures ranging from 30° to 0° C. Approximately the variations of mobility with latitude are also variations with temperature, and as such they are in qualitative agreement with the results obtained by Phillips.[a] However, changes in temperature can not be the entire cause of the observed variation of the mobilities with latitude, since the means for each sign remained practically constant throughout the first year of Cruise IV and all of Cruise VI. It is possible that the atmospheric conditions off the west coast of South America are responsible, at least in part, for the relatively high mobilities found on Cruise V between 40° south and 40° north. This appears especially probable when one recalls that the easterly winds are largely deprived of their water-vapor content in their passage over the Andes. In fact, the relative humidity as observed on the vessel when in these regions was considerably lower than that usually observed at sea.

In general, the consistency of the mobility results may be taken to indicate the satisfactory nature of the conductivity and ionic-content observations of the *Carnegie*.

THE RADIOACTIVE CONTENT OF SEA AIR.

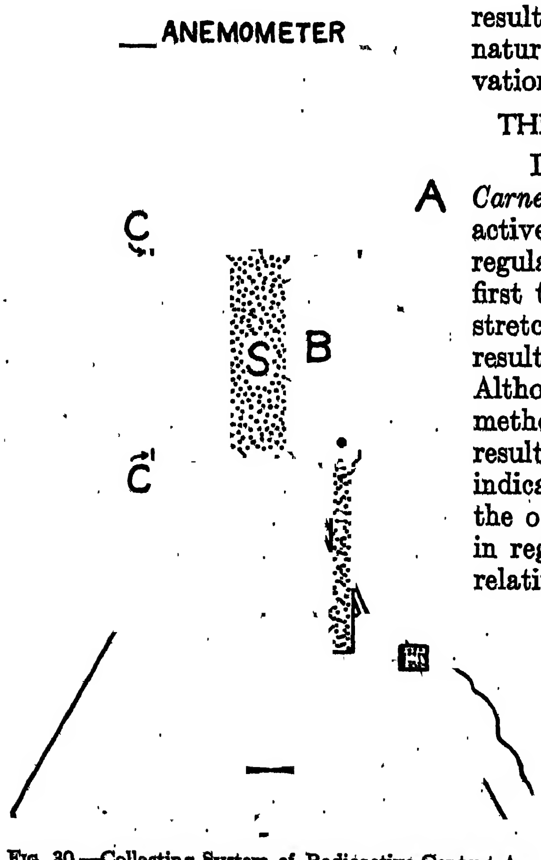

FIG. 30.—Collecting System of Radioactive-Content Apparatus used on the *Carnegie*.

During each of the six cruises of the yacht *Carnegie* observations for determining the radioactive content of the air have formed a part of the regular program. These measurements during the first three cruises (1909–1914) were made by the stretched-wire method of Elster and Geitel, and the results have been published from time to time.[b] Although observations by the Elster and Geitel method can at best yield only relative values, the results during the first three cruises consistently indicated a much smaller radioactive content over the oceans than exists normally over land and less in regions far removed from land than in regions relatively near land. Further, it was evident from the shape of the decay-curves that radioactive deposits obtained over the great oceans consist almost entirely of the decomposition products of radium emanation.

It was early realized, however, that there was a great need for absolute determinations of the amount of radium emanation normally present in the air over the ocean areas, and with this end in view an apparatus of the Gerdien type was designed by W. F. G. Swann in 1915 for use aboard the *Carnegie*. The essential features of the collecting system are shown in Figure 30, where *A* represents a vertical copper cylinder 20 cm. in diameter and 64 cm. long, and *B* an insulated wooden cylinder 12 cm. in diameter and 12 cm. long within and concentric with *A*. Air is drawn through the main

[a] *Proc. Roy. Soc. A*, vol. 78 (1907), p. 167.
[b] *Terr. Mag.*, vol. 15 (1910), pp. 83–91; vol. 19 (1914), pp. 127–170; and vol. 20 (1915), pp. 13–48.

TABLE 89.—*Summary of Final Results of Observations Made on the Carnegie for Determining Q, the Radium-Emanation Content of the Air.*

General location	First observation of series			Last observation of series			No. of obs'ns in series	Q[1] (Unit = 10^{-18} cur./cm³)
	Lat.	Long. E. of Gr.	Date	Lat.	Long. E. of Gr.	Date		
	°	°	*1915*	°	°	*1915*		
Pacific Ocean, near Panama..	6 N	280	Apr 14	....	....	....	1	5.6
Pacific Ocean..............	4 N	279	Apr 15	4 N	264	Apr 24	10	1.7
Pacific Ocean..............	4 N	265	Apr 25	10 N	252	May 3	10	3.6
Pacific Ocean..............	10 N	251	May 4	17 N	228	May 12	10	1.8
Pacific Ocean..............	18 N	224	May 13	21 N	204	May 20	9	1.2
Pacific Ocean..............	22 N	201	Jul 4	52 N	190	Jul 19	10	1.0
Bering Sea..................	59 N	188	Aug 10	39 N	164	Aug 27	10	[3] 5.4
Pacific Ocean..............	37 N	165	Aug 28	17 N	166	Sep 13	11	0.5
Pacific Ocean..............	15 N	165	Sep 14	4 N	163	Sep 28	12	0.0
Pacific Ocean..............	3 N	162	Sep 29	24 S	157	Oct 19	11	1.1
Pacific Ocean..............	26 S	156	Oct 20	45 S	173	Nov 2	12	[3] 3.6
						1916		
Southern Ocean............	49 S	178	Dec 9	60 S	291	Jan 3	10	0.0
			1916					
Southern Ocean............	60 S	295	Jan 4	54 S	10	Jan 24	10	0.3
Southern Ocean............	54 S	15	Jan 25	51 S	78	Feb 9	10	0.0
Southern Ocean............	44 S	86	Feb 12	57 S	112	Mar 2	10	0.6
Southern Ocean............	44 S	131	Mar 13	48 S	168	Mar 29	8	0.5
Near New Zealand..........	46 S	171	Mar 30	45 S	173	Mar 31	2	0.6
Pacific Ocean..............	44 S	178	May 22	23 S	191	Jun 3	6	[2] 2.4
Pacific Ocean..............	12 S	189	Jun 20	14 N	146	Jun 16	7	1.0
Pacific Ocean..............	45 N	159	Aug 23	40 N	231	Sep 18	9	[4] 12.9
Pacific Ocean..............	17 N	245	Nov 13	6 N	252	Nov 27	3	8.4
Pacific Ocean..............	1 S	241	Dec 2	30 S	251	Dec 22	5	0.5
			1917			*1917*		
Pacific Ocean..............	27 S	250	Jan 2	17 S	232	Jan 14	9	1.2
Pacific Ocean..............	38 S	220	Jan 29	49 S	244	Feb 8	7	1.4
Atlantic Ocean.............	56 S	294	Feb 17	54 S	297	Feb 19	2	[5] 29.7
Atlantic Ocean.............	39 S	303	Dec 10	51 S	298	Dec 18	5	[5] 30.0
						1918		
Pacific Ocean..............	56 S	280	Dec 31	53 S	280	Jan 1	2	1.7
			1918					
Pacific Ocean..............	32 S	279	Feb 10	21 S	280	Feb 16	4	0.0
Pacific Ocean..............	13 S	282	Feb 21	....	....	....	1	[5] 6.7
Pacific Ocean..............	11 S	282	Mar 30	16 S	266	Apr 6	6	0.0
Pacific Ocean..............	3 N	281	Apr 21	5 N	281	Apr 22	2	0.9
Atlantic Ocean.............	12 N	280	May 13	33 N	284	May 31	11	2.2
Atlantic Ocean.............	34 N	286	Jun 1	36 N	285	Jun 3	2	1.8
			1919			*1919*		
Atlantic Ocean.............	36 N	286	Oct 20	38 N	298	Oct 24	3	[6] 9.2
Atlantic Ocean.............	37 N	298	Oct 25	39 N	330	Nov 6	6	4.5
Atlantic Ocean.............	35 N	334	Nov 10	25 N	340	Nov 16	6	3.5
Atlantic Ocean.............	22 N	340	Nov 18	10 N	344	Nov 29	3	[7] 29.3
Atlantic Ocean.............	9 N	345	Nov 30	7 N	347	Dec 2	3	[7] 8.2
Atlantic Ocean.............	7 N	347	Dec 3	3 N	359	Dec 14	10	[7] 1.9
Atlantic Ocean.............	0	3	Dec 20	13 S	345	Dec 29	9	0.7
			1920			*1920*		
Atlantic Ocean.............	19 S	339	Jan 1	33 S	318	Jan 12	7	0.8
Atlantic Ocean.............	34 S	312	Jan 15	41 S	312	Feb 27	4	0.2
Atlantic Ocean.............	46 S	335	Mar 4	32 S	2	Mar 15	9	1.1
Atlantic Ocean.............	25 S	7	Mar 18	14 S	2	Mar 24	5	[7] 1.9
Atlantic Ocean.............	15 S	0	Mar 25	16 S	356	Mar 26	2	[7] 7.3
Atlantic Ocean.............	17 S	352	Apr 4	37 S	358	Apr 17	8	0.4
Atlantic and Indian Oceans..	38 S	10	Apr 21	26 S	65	Jun 7	6	0.5
Indian Ocean...............	11 S	65	Jun 12	2 S	63	Jun 16	5	0.8
Indian Ocean...............	4 N	62	Jun 19	11 N	66	Jun 24	5	0.4
Indian Ocean...............	9 N	72	Jun 26	6 S	96	Aug 4	10	[8] 3.6
Indian Ocean...............	8 S	96	Aug 5	27 S	78	Aug 16	8	0.2
Indian Ocean...............	32 S	76	Aug 20	37 S	117	Oct 4	3	0.4
Indian Ocean...............	46 S	171	Oct 19	45 S	173	Oct 20	2	[9] 7.3
Pacific Ocean..............	40 S	219	Dec 3	22 S	217	Dec 17	9	0.9
			1921			*1921*		
Pacific Ocean..............	4 N	202	Jan 13	....	....	....	1	0.1
Pacific Ocean..............	32 N	231	Mar 31	29 N	227	Apr 2	3	1.1
Pacific Ocean..............	34 N	204	May 7	34 N	206	May 8	2	1.2
Pacific Ocean..............	34 N	213	May 11	34 N	216	May 12	2	1.2
Pacific Ocean..............	34 N	217	May 13	9 N	219	May 26	9	2.1
Pacific Ocean..............	1 S	210	Jun 4	10 S	200	Jun 14	7	0.4

[1] Values of Q less than 0.05 are recorded as 0.0. [2] Region of New Zealand and Samoa. [3] Includes several very large values apparently influenced by nearness of land. [4] Near Aleutian Islands. [5] Near South American coast. [6] Near North American coast. [7] Near African coast. [8] Near Ceylon. [9] Near New Zealand.

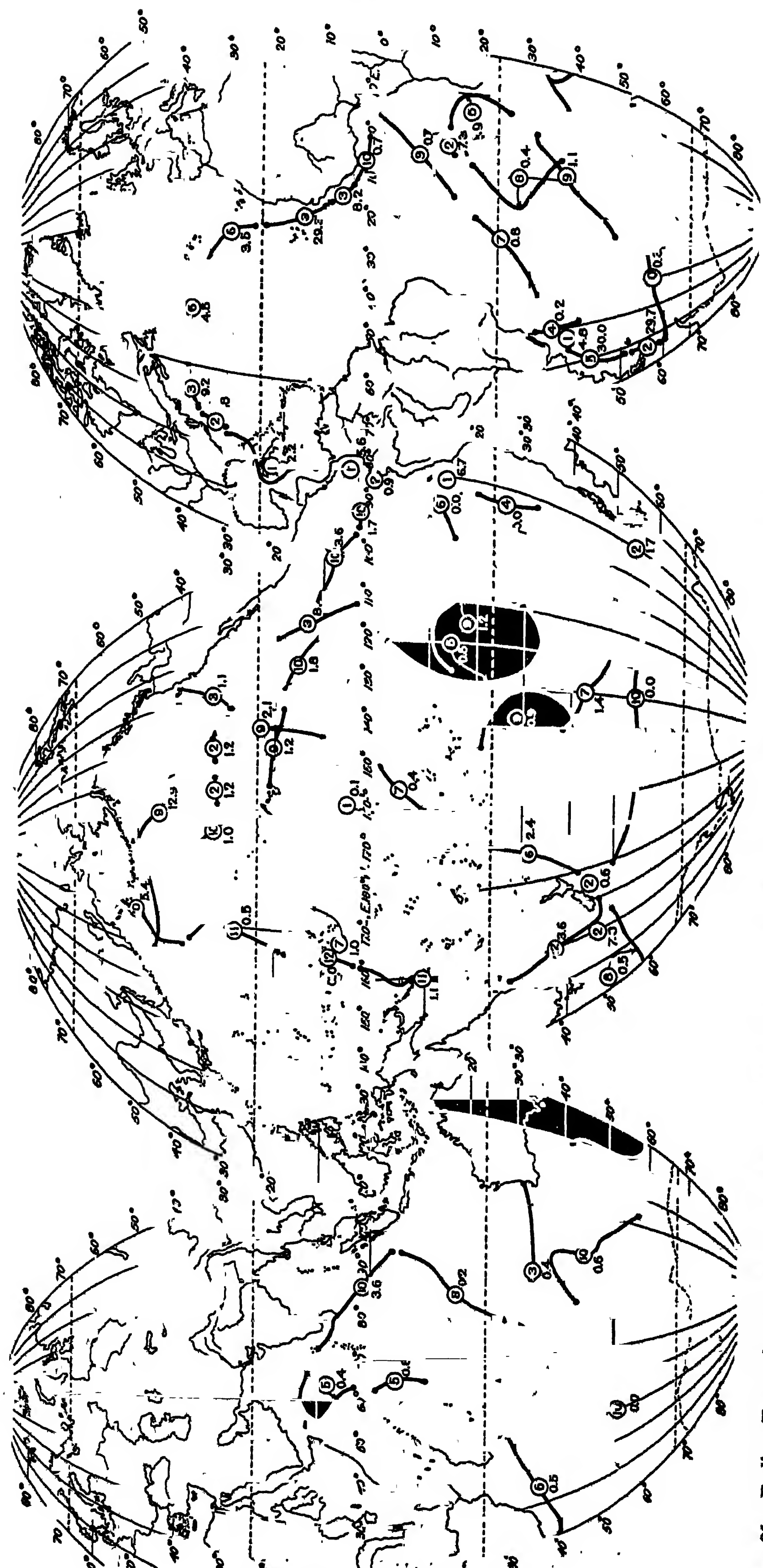

FIG. 31.—Radium-Emanation Content of the Air from Observations on the *Carnegie*, 1915–1921, showing Number of Observations and Mean Values obtained for Different Sections of the Cruises. (J. Paul Goode Base-Map, Copyright by University of Chicago Press.)

cylinder by a motor-driven fan, and the positively-charged radioactive deposits are collected on a sheet of copper foil forming the removable surface of cylinder B, which is maintained at a negative potential of 2,000 to 2,500 volts. An anemometer calibrated *in situ* gives the total volume of air drawn through the tube during the collection of deposit. After a collecting period of 30 minutes, the foil is earthed and quickly placed inside a suitable ionization chamber with its activated surface facing inwards towards the central system (a thin rod) of the chamber. The walls of the ionization chamber are kept at a potential of at least 100 volts, and the decay-curve of the deposit is obtained by noting the successive times required for charging the central cylinder and its single-fiber Wulf electrometer to a given fixed potential, starting each time from earth potential. For further details of the apparatus and its accessory equipment, Swann's description should be consulted (see Vol. III, pp. 390–392).

On pages 393 to 396 of the publication just referred to, Swann also gives the theory of the method employed in the determination of the emanation content of the atmosphere from these observations, together with a discussion of the results obtained from a preliminary reduction of the observations made during the year April 1915 to March 1916. Observations with the above apparatus were continued throughout the remainder of Cruise IV, which ended at Buenos Aires in March 1917; during Cruise V, December 1917 to June 1918; and, with but slight modifications of the apparatus, throughout Cruise VI, October 1919 to November 1921.

In the published preliminary values for the first year's work the capacity of the ionization chamber and its electrometer was taken to be 12.0 cm. in accordance with an approximate determination made by the present author in 1915 under unfavorable ship conditions, pending more accurate determinations. Numerous careful observations in the laboratory of the Department at Washington have since shown the effective value to be only about 70 per cent of that which was assumed in the preliminary reductions. Accordingly, in order to facilitate comparison of the results of all observations for the period 1915–1921, the first year's observations were reduced on the basis of the finally adopted capacity. During this work advantage was taken of the opportunity to change slightly the grouping which enters into certain of the published mean values in order that the new means might correspond in somewhat greater detail to such conditions as wind direction and distance from land.

The mean values given in Table 89 were reduced by Captain J. P. Ault and the author, and are given in detail in the Table of Final Results in the report on the atmospheric-electric observations on the *Carnegie*, 1915–1921 (see this volume, pp. 212–265). Figure 31 shows the distribution of the observations and the actual courses followed by the vessel between the first and last observations entering into each of the mean values of Table 89. The encircled numbers of the figure give the number of decay-curves corresponding to each section of the several cruises and the corresponding mean values (in 10^{-18} curie per c. c.) are given by the numbers near the circles. The course of vessel, force and direction of wind, temperature, relative humidity, and details are given in the Table of Final Results; see pages 2 and 197 regarding the observers directly responsible for the observations.

In the column of Table 89 headed "No. of obs'ns" is given the number of separate collections of deposit entering into a given mean value of Q. In general, only one collection was made daily, although there were, on the whole, many days when observations were not practicable for various reasons. The total number of decay-curves actually obtained during the period in question was nearly 400, and of these over 300 correspond to regions far removed from land. The mean value of the radium-emanation content of sea air derived from all observations is 2.6×10^{-18} curie per cubic centimeter, each of the tabular values being weighted according to the number of separate collec-

tions upon which it is based. However, many of the observations made relatively near to large bodies of land give values far in excess of the general mean. If all values that show marked land effects are eliminated, there remain 169 well-distributed observations in the Pacific Ocean giving a mean value of 1.3×10^{-18} curie per cubic centimeter, 79 in the Atlantic with a mean value of 1.7×10^{-18} curie per cubic centimeter, 37 in the Indian with a mean value of 1.3×10^{-18} curie per cubic centimeter, and 48 in the Southern Ocean (south of latitude 50° south) with a mean value of only 0.3×10^{-18} curie per cubic centimeter. We thus have a total of 333 observations, representative of practically all accessible ocean areas, which give a mean value of 1.2×10^{-18} curie per cubic centimeter.

Simpson and Wright, on a journey from England to Cape Town, using the Elster and Geitel method, found an interesting relation between latitude and the radioactive content of the air.[a] Their observations indicated that over the Atlantic, in both the northern and southern hemispheres, the amount of emanation increased from latitude 40° toward the equator, but that within 10° of the equator the emanation content was again low. There were not enough observations aboard the *Carnegie* in the North Atlantic to give any information regarding such a variation with latitude. However, in the South Atlantic and in the Indian oceans the number and distribution of observations is ample for this purpose, while the vessel crossed the Pacific Ocean several times during the years 1915 to 1921 between latitudes approximately 50° north and 50° south. The results give no evidence of a general relation between latitude and the absolute amounts of radium emanation present in the air over the oceans, except that over the Southern Ocean there is even less emanation present than over the main areas of the other oceans, as already pointed out both by Simpson and Wright and by Swann. It would thus appear that the relation obtained by Simpson and Wright either is attributable to meteorological effects on observations by the Elster and Geitel method, or else it represents a relatively local condition peculiar to the region covered by their observations.

As shown by Figure 31, the observations on the *Carnegie* in the North Atlantic were relatively few in number and chiefly in latitudes 30° to 40°. The results, so far as they go, seem to indicate a somewhat higher emanation-content for mid-ocean over the Atlantic than over the Pacific and Indian oceans, but the amounts for the regions visited are not so large as to be in agreement with the observations of Eve,[b] who, by the Elster and Geitel method, obtained results in latitudes approximately 50° north which were comparable with his land values.

It is of interest to note that there are four regions where outstanding large amounts of radioactive deposits were obtained, namely: Bering Sea and waters to the south of the Aleutian Islands; the waters adjacent to New Zealand; near the Argentine coast; and off the French West African coast. In the latter region the observations were made during the season when the prevailing winds (harmattan) carry considerable quantities of dust out to sea, sometimes over distances of several hundred miles. The deck of the *Carnegie* was for several days covered with a finely divided red dust while in these waters. In each of the other three regions just mentioned the winds encountered were, in general, from the direction of land areas.

Simpson,[c] in 1916, pointed out the insufficiency of the radioactive content of sea air to account for the atmospheric ionization found to exist over the oceans. Since no absolute determinations of the amount of radium emanation over the oceans were at that time available, his conclusions were based upon the results of his observations with the Elster and Geitel apparatus, indicating that over the ocean there was only 5 per cent of the radium emanation found over land. This estimate he conservatively doubled,

[a] *Proc. Roy. Soc. A.*, vol. 85 (1911), p. 186.
[b] *Terr. Mag.*, vol. 14 (1909), p. 25.
[c] *Monthly Weather Review*, vol. 44 (1916), pp. 115–122.

and on this basis found that "using the most liberal estimate, all the known radioactive matter over the sea is able to produce only 0.18 ion per cubic centimeter per second." Swann (Vol. III, p. 414), in his discussion of the preliminary results of the *Carnegie* observations for the year April 1915 to March 1916, concluded that "the average amount of radium emanation over the Pacific and sub-Antarctic oceans, as determined by the results of the present cruise, is capable of accounting for the production of about 0.05 ion per cubic centimeter per second." We have now available the results of a sufficient number of well-distributed absolute determinations of the radium-emanation content of sea air to leave no doubt whatever as to the correctness of the conclusions of Simpson and of Swann, just cited. On the basis used by them we now find that, when due allowance is made for all regions showing unmistakable land effect, there remain ocean areas totaling at least half the surface of the Earth over which the radium-emanation content is of the order of only 1 per cent of that found over land and where, as a consequence, the rate of ionization due to radium emanation must be less than 0.03 ion per cubic centimeter per second.

While the above results support the prevailing view that winds blowing from land areas are responsible for the radioactive content of sea air, they also have an interesting bearing upon the question of the possible solar origin of an appreciable portion of the disintegration products of radium found in the lower strata of the Earth's atmosphere, which has been advanced by some investigators. For example, a striking correlation has recently been shown by Bongards[a] between the results of his own radioactive-content measurements at Lindenburg in Germany and of observations made at the same time by Smith and Wright at Manila. The close agreement in the trend of these parallel measurements over a period of four months if viewed alone is certainly suggestive of a common, perhaps extra-terrestrial, origin of a considerable portion of the radioactive content of the air at the two stations. However, such an assumption is not consistent with the very low values of radium-emanation content now shown to exist in the air over the oceans, since radioactive matter from such a source would be distributed over the sea as well as over land. We must, therefore, conclude from the ocean observations that the amount of radium emanation which may be assumed to reach the lower strata of our atmosphere from an extra-terrestrial source is negligibly small.

THE PENETRATING RADIATION OVER THE OCEANS.

The penetrating radiation, or, more properly, the ionization of the air in a sealed copper vessel, was regularly observed on the *Carnegie* during cruises IV and VI. The same electrometer and ionization chamber were used in the observations for both cruises, the former being a unifilar electrometer of the Einthoven-Wulf type and the latter a sheet-copper cylinder whose axis and diameter were each about 30.5 cm. The only change in the arrangement for Cruise VI from that of Cruise IV was an increase of about 2.5 cm. in the length of the connection between electrometer and chamber, which caused an increase of 4 per cent in the capacity. An improvement in the provision for sealing the chamber was also provided, but this affected neither the volume of the chamber nor the electrical capacity of the system.

On both cruises many 24-hour series were made for determining the diurnal variation. A study of the results obtained confirmed Swann's preliminary conclusions as given in Volume III, page 417; that is, while there were always fluctuations in value throughout the day (see Table of Final Results, pp. 212–265), these were small and irregular. There was, however, not sufficient agreement among the results even in the Pacific Ocean, for which the observations are most plentiful, to justify the formation of mean diurnal-variation curves. Such curves apparently would represent only a mean value of many irregular fluctuations and not at all the average values corresponding to a

[a] *Physik. Zs.*, vol. 24 (1924), p. 395.

TABLE 90.—*Ionization in a Closed Vessel Observed on the Carnegie during Cruises IV and VI, Giving 3-Month and 12-Month Means for 20-Degree Belts of Latitude.*[1]

Group values

Latitude belt	February, March, April	May, June, July	August, September, October	November, December, January	February to January: No. days	February to January: Means, Weighted	February to January: Means, Arithmetic
	March 1915 to February 1916 (approximate epoch 1915.7) during Cruise IV						
° °	*ions/cc/s*	*ions/cc/s*	*ions/cc/s*	*ions/cc/s*		*ions/cc/s*	*ions/cc/s*
60 N–40 N	....	3.41 (4)	3.45 (16)	....	20	3.44	3.43
40 N–20 N	3.41 (1)	3.53 (13)	3.43 (12)	....	26	3.46	3.46
20 N– 0 N	[2]3.20 (21)	3.44 (16)	3.40 (17)	....	54	3.35	3.35
0 S–20 S	....	....	3.42 (9)	....	9	3.42	3.42
20 S–40 S	3.30 (5)	....	2.94 (12)	....	17	3.05	3.12
40 S–60 S	3.47 (13)	....	3.03 (3)	3.49 (33)	49	3.45	3.33
Weighted means.....	3.31 (40)	3.26 (33)	3.32 (69)	3.49 (33)	175	3.38	3.35
	March 1916 to February 1917 (approximate epoch 1916.7) during Cruise IV						
60 N–40 N	....	....	2.73 (10)	....	10	2.73	2.73
40 N–20 N	....	2.40 (2)	....	....	2	2.40	2.40
20 N– 0 N	....	2.92 (17)	....	2.68 (8)	25	2.84	2.80
0 S–20 S	....	2.77 (5)	....	3.25 (15)	20	3.13	3.01
20 S–40 S	3.10 (1)	3.06 (8)	....	2.91 (20)	29	2.96	3.02
40 S–60 S	3.37 (30)	2.64 (5)	....	....	35	3.27	3.00
Weighted means.....	3.36 (31)	2.86 (37)	2.73 (10)	2.98 (43)	121	3.02	2.83
	March 1915 to February 1917 (approximate epoch 1916.2) for all Cruise IV						
60 N–40 N	....	3.41 (4)	3.17 (26)	....	30	3.20	3.29
40 N–20 N	3.41 (1)	3.38 (15)	3.43 (12)	....	28	3.40	3.41
20 N– 0 N	3.20 (21)	3.17 (33)	3.40 (17)	2.68 (8)	79	3.19	3.11
0 S–20 S	....	2.77 (5)	3.42 (9)	3.25 (15)	29	3.22	3.15
20 S–40 S	3.27 (6)	3.06 (8)	2.94 (12)	2.91 (20)	46	2.99	3.04
40 S–60 S	3.40 (43)	2.64 (5)	3.03 (3)	3.49 (33)	84	3.38	3.14
Weighted means.....	3.33 (71)	3.05 (70)	3.25 (79)	3.17 (76)	296	3.23	3.19

Latitude belt	February, March, April	May, June, July	August, September, October	November, December, January	February to January: No. days	February to January: Means, Weighted	February to January: Means, Arithmetic
	October 1919 to October 1920 (approximate epoch 1920.5) during Cruise VI						
° °	*ions/cc/s*	*ions/cc/s*	*ions/cc/s*	*ions/cc/s*		*ions/cc/s*	*ions/cc/s*
60 N–40 N	....	....	....	....	.....	....	....
40 N–20 N	....	....	4.04 (9)	4.02 (14)	23	4.03	4.03
20 N– 0 N	....	4.09 (13)	....	4.61 (19)	32	4.40	4.35
0 S–20 S	3.98 (8)	4.07 (6)	3.62 (8)	4.08 (13)	35	3.92	3.94
20 S–40 S	4.03 (23)	3.74 (8)	3.89 (14)	4.45 (7)	52	4.00	4.03
40 S–60 S	4.36 (10)	....	4.22 (6)	....	16	4.31	4.29
Weighted means.....	4.10 (41)	3.98 (27)	3.89 (37)	4.30 (53)	158	4.10	4.18
	November 1920 to November 1921 (approximate epoch 1921.4) during Cruise VI						
60 N–40 N	....	....	....	....	.....	....	....
40 N–20 N	3.44 (18)	3.07 (16)	3.92 (6)	3.62 (7)	47	3.41	3.51
20 N– 0 N	....	2.91 (11)	3.78 (11)	3.39 (5)	27	3.35	3.36
0 S–20 S	....	3.07 (15)	3.43 (9)	3.53 (9)	33	3.29	3.34
20 S–40 S	....	....	3.42 (32)	3.79 (13)	45	3.53	3.60
40 S–60 S	....	....	....	4.53 (6)	6	4.53	4.53
Weighted means.....	3.44 (18)	3.03 (42)	3.55 (58)	3.76 (40)	158	3.45	3.67
	October 1919 to November 1921 (approximate epoch 1920.9) for all Cruise VI						
60 N–40 N	....	....	....	....	.....	....	....
40 N–20 N	3.44 (18)	3.07 (16)	3.99 (15)	3.89 (21)	70	3.61	3.60
20 N– 0 N	....	3.55 (24)	3.78 (11)	4.35 (24)	59	3.92	3.89
0 S–20 S	3.98 (8)	3.35 (21)	3.46 (17)	3.86 (22)	68	3.62	3.66
20 S–40 S	4.03 (23)	3.74 (8)	3.57 (46)	4.02 (20)	97	3.79	3.84
40 S–60 S	4.36 (10)	....	4.22 (6)	[3]4.53 (6)	22	4.37	4.37
Weighted means.....	3.91 (59)	3.40 (69)	3.68 (95)	4.07 (93)	316	3.78	3.87

[1] Includes complete diurnal variation series (19 hours or more) on 14 days during Cruise IV and on 4 days during Cruise VI, as also 25 incomplete series on Cruise IV and 17 incomplete series on Cruise VI, each mean counting as one day.

[2] Value 8.22 (at 10h 7) on March 22, 1915, omitted in mean, as apparently it is erratic

[3] Value 7.32 on November 21, 1920, omitted in mean, as relative humidity was 100 per cent.

definite type of variation. In fact, the greater the number of series one combines into a mean curve the more nearly the resulting curve approximates a straight line.

In addition to the diurnal-variation series, daily morning observations were made on the *Carnegie* on 296 days and on 316 days during cruises IV and VI, respectively. The mean rates of production of ions in the ionization chamber were 3.2 and 3.8 ions per cubic centimeter per second on the fourth and sixth cruises, respectively. While this change is in a direction consistent with that deduced from the ionic-content observations, it is much larger than necessary to account for the actual increase in the ionic content which, as we have seen from Table 85, is of the order of 60 ions per cubic centimeter for either sign.

However, separate examination of Table 90, summarizing the data obtained during each of the four years over which these cruises extended, shows that the mean yearly results differ considerably among themselves. While the differences between the yearly means may represent actual differences in the penetrating radiation, this can not be accepted definitely as a conclusion.

It should be stated that, although the ionization vessel was carefully cleaned, filled with filtered air, and sealed at the beginning of each cruise, it became necessary toward the middle of each cruise (because of accidents caused by rough seas) to dismantle the apparatus and refill the chamber with air from mid-ocean regions. The radium emanation contained in sea air well removed from land, as stated in the preceding section, is on the average about 1 per cent only of that observed at land stations, while for some regions no trace of any radioactivity was indicated by the observations. It may be, therefore, that the drop of over 10 per cent from the mean value of the first year to that of the second for each cruise is partly attributable to the circumstances connected with the necessary repairs and refilling.

While there has been no determination of the amount of ionization to be attributed to the copper ionization-vessel, this probably does not much exceed 2 ions per cubic centimeter per second, since it was not uncommon to observe a total ionization of the order of 2.5 ions per cubic centimeter per second, with several extreme cases going even below 2.0.

SOME GENERAL CONSIDERATIONS ON ATMOSPHERIC ELECTRICITY FROM THE WORK OF THE CARNEGIE, 1915–1921.

The foregoing studies emphasize the importance of the practically worldwide atmospheric-electric survey of the oceans because of (1) the comparative freedom from local disturbance at sea as contrasted with land stations and (2) the greater homogeneity of resulting data both for investigating the distribution and the variations with time.

As regards the absolute values, the mean of the potential gradient for 1915 to 1921 (about 130 volts per meter) observed over the oceans is of the same order as the average value deduced from a number of widely distributed land stations. The average numbers of positive and negative ions in sea air (of the order of 600 and 500 ions per cubic centimeter, respectively), while perhaps somewhat smaller than average land values, are nevertheless of the same order of magnitude. In view of the wide distribution of the sea observations and the greater constancy of values found over the oceans, it is probable that the general mean value of the ionic content is more accurately known for the oceans than for the continental areas. Similar remarks apply also with reference to the data for conductivity and air-earth current-density, except that here the ocean results indicate a somewhat greater current-density over the oceans than over land.

Only as regards the radioactive contents of sea water and sea air do the quantities observed at sea differ greatly from those observed on the continents. For example, Hewlett[a] found that the radium-content of sea-salt collected on the *Carnegie* from areas far removed from land was negligibly small as compared with the values found by Joly and others for salt collected near land. The present writer (pp. 421) has shown, in

[a] HEWLETT, C. W. The Radium-Content of Sea-Salt Specimens Collected on Cruise IV of the *Carnegie*. *Terr. Mag.*, vol. 22 (1917), pp. 173–181.

confirmation of similar preliminary conclusions by Simpson and by Swann, that the radium-emanation content of sea air in regions far removed from land is entirely inadequate for producing the atmospheric ionization found in those regions. The results of the observations for determining the radioactive content of the air obviously also are confirmatory of Hewlett's result regarding the radium-content of sea-salt. For if appreciable amounts of radium were contained in mid-ocean water, its emanation would certainly escape into the air, and if the amounts of emanation in the air over mid-ocean had been a few per cent of that found over land it would have been detected and measured in course of the observations made at the same time for the radioactive content of the air.

While continuous observations have long been made at many land stations to obtain data regarding the diurnal and annual variations of atmospheric electricity, these did not result in the adoption of a generalized view of either of these phenomena. This is especially true with reference to the potential gradient for which a much greater amount of observational data is available than for any of the other elements. The chief reason for this condition is the well-known fact that the results of land observations from different stations usually differ considerably among themselves, even for regions not far distant from each other. However, the results given in the preceding pages, especially those regarding the diurnal variations of the potential gradient and the density of the air-earth current, show that these phenomena can not be subject to interpretation wholly on the basis of local phenomena, even though the existence of these, to greater or lesser degree, may be unquestioned and their characteristic features well determined from adequate observational data.

As regards the annual variation of the potential gradient, this, too, was long thought to be a phenomenon dependent on and associated with the local progression of the seasons. However, as the results of additional and extended observational series have become available from both the Arctic and Antarctic regions, the evidence has grown continually stronger in favor of an annual variation progressing according to time of year rather than according to local seasons. Further, the results given in the preceding report by Doctor Bauer concerning the annual variation of the potential gradient (see pp. 382–384) make it appear increasingly probable that the fundamental wave of the annual variation may be of about the same general type over the various oceans.

The regular increase with increasing latitude of the average values of the potential gradient in all regions visited by the *Carnegie* (60° N to 60° S) also suggests the predominance of a world-wide control of the chief features of this element.

It should be noted in passing that certain generalizations based on the results of land observations representative of only a small fraction of the Earth's surface have not been found to hold even approximately for the Earth as a whole. On the other hand, as shown by the writer in an earlier publication,[a] no great difficulties are encountered in adapting most of the land results to the general scheme suggested by the results of the ocean observations.

Considerations like these indicate the importance of obtaining more observations, both at sea and over land, of sufficient precision and general accuracy to contribute decisive evidence regarding the nature of the phenomena under discussion. In the meantime, it appears altogether likely that our progress in unraveling and explaining the mysteries of the Earth's electric charge and of the associated atmospheric-electric phenomena will be facilitated by a greater concentration of attention on world-wide features, and especially on those variations which apparently progress according to universal rather than local mean time.

The author desires to make record of the constructive suggestion and criticism so generously given in the preparation of these atmospheric-electric studies by his colleagues, particularly by Messrs J. A. Fleming and J. P. Ault.

[a] *Terr. Mag.*, vol. 28 (1923), pp. 73–81.

INDEX, MAGNETIC RESULTS.

[See separate index for atmospheric-electric results.]

INDEX, ATMOSPHERIC-ELECTRIC RESULTS.